2

VOLUME 13, NO. 1
JANUARY 1981

A093406

(11) Jan 81

(6)

THE SHOCK AND VIBRATION DIGEST, Volume 13, Number 1.

A PUBLICATION OF
THE SHOCK AND VIBRATION
INFORMATION CENTER
NAVAL RESEARCH LABORATORY
WASHINGTON, D.C.

389
004

(12) 103

(10) Judith Nagle-Eshleman

OFFICE OF
THE UNDER
SECRETARY
OF DEFENSE
FOR RESEARCH
AND
ENGINEERING

[redacted]

389004 slt

THE SHOCK AND VIBRATION DIGEST

Volume 13, No. 1
January 1981

A publication of

THE SHOCK AND VIBRATION
INFORMATION CENTER

Code 5804, Naval Research Laboratory
Washington, D.C. 20375

Henry C. Pusey
Director

Rudolph H. Volin

J. Gordan Showalter

Carol Healey

Elizabeth A. McLaughlin

The Shock and Vibration Digest is a monthly publication of the Shock and Vibration Information Center. The goal of the Digest is to provide efficient transfer of sound, shock, and vibration technology among researchers and practicing engineers. Subjective and objective analyses of the literature are provided along with news and editorial material. News items and articles to be considered for publication should be submitted to:

Dr. R.L. Eshleman
Vibration Institute
Suite 206
101 West 55th Street
Clarendon Hills, Illinois 60514

Copies of articles abstracted are not available from the Shock and Vibration Information Center (except for those generated by SVIC). Inquiries should be directed to library resources, authors, or the original publishers.

This periodical is for sale on subscription at an annual rate of $100.00. For foreign subscribers, there is an additional 25 percent charge for overseas delivery on both regular subscriptions and back issues. Subscriptions are accepted for the calendar year, beginning with the January issue. Back issues are available by volume (12 issues) for $15.00. Orders may be forwarded at any time, in any form, to SVIC, Code 5804, Naval Research Laboratory, Washington, D.C. 20375. Issuance of this periodical is approved in accordance with the Department of the Navy Publications and Printing Regulations, NAVEXOS P-35.

SVIC NOTES

"The trouble with the future is that it usually arrives before we're ready for it."
-- Arnold H. Glasow

1981 is here and I think we are ready. This time of year is for reflecting and planning. As I look back at 1980 with some satisfaction, I see some trends that are likely to influence our future actions. In this DIGEST, for example, there has been a significant increase in the quantity of technical literature in our field. There were nearly 21 percent more abstracts published in 1980 than in 1979. Either more work is being done or there is more emphasis on publication. Whatever the reason, this Center will have a bigger job of screening and analysis of the available literature.

The 51st Shock and Vibration Symposium was especially successful. Feedback from some of the participants indicates that more new developments were presented than at most previous symposia. It was also evident that there was a greater percentage of new participants than we usually have. Many of these, now just beginning in our field, will replace the old timers as they fade form the scene. I believe we have an obligation to our new associates to bring them up to date on past developments, to provide all the background required for their pursuit of exciting new problems. We must consider new ways of packaging past research results so that such information may be absorbed with minimum effort.

At the 51st Symposium, SVIC was offered a challenge by Mr. Robert Dyrdahl of Boeing, who gave an outstanding plenary address on shock. Bob suggested that we should establish a document that will provide explanations, guidelines and methods for establishing design loads and dynamics requirements and specifications for necessary and sufficient qualifications for shock and vibration. This document should be continually updated, with modifications or additions resulting from discussions at each annual symposium. Such a publication would be a tool to provide increased confidence in our approaches to dynamics problems, the best of which would be included as a part of the document. It would also be useful for on-the-job training of new engineers. We have accepted the challenge and are now exploring ways to accomplish this difficult task.

So, as we begin 1981, let's try to be ready for it. If you have any thoughts on how this DIGEST or SVIC can serve the community better, please write to Dr. Eshleman or me. My best wishes to all for a prosperous and successful year.

H.C.P.

#100 00
NRL

A 21

ANNUAL SERVICE PACKAGE* OF THE SHOCK

PUBLICATIONS

BULLETINS

a collection of technical papers offered at the SHOCK AND VIBRATION SYMPOSIA published once a year. *Catalog listing back issues available from SVIC.*

DIGEST

a monthly publication of THE SHOCK AND VIBRATION INFORMATION CENTER containing abstracts of the current literature, continuous literature review, feature articles, news briefs, technical meeting calendar, meeting news, and book reviews.

MONOGRAPHS

a series of books on shock and vibration technology. Each author surveys the literature, extracts significant material, standardizes the symbolism and terminology and provides an authoritative condensed review with bibliography. *Brochure listing available monographs can be obtained from SVIC.*

SPECIAL PUBLICATIONS

special technology surveys, facility surveys, proceedings of special seminars and other publications as needed.

**For information on obtaining the SVIC Service Package including publications and services, contact the SVIC, Naval Research Laboratory, Code 5804, Washington, D.C. 20375, (202) 767-3306. These publications and services may also be obtained on an individual basis.*

AND VIBRATION INFORMATION CENTER

INFORMATION SERVICES

DIRECT INFORMATION SERVICE*	the Center handles requests for information via mail, telephone, and direct contact. The Center technical specialists, who are experts in the shock and vibration field, have the SVIC computer implemented SHOCK AND VIBRATION INFORMATION BASE at their disposal.
WORKSHOPS	workshops on shock and vibration technology are organized and sponsored by the Center. Experts on specialized technology give lectures and write articles for the workshop proceedings.
SYMPOSIA	annual shock and vibration symposia bring together working scientists and engineers for formal presentations of their papers and for informal information exchanges.

**See inside back cover for details*

EDITORS RATTLE SPACE

CONTINUING EDUCATION WITH SEMINARS AND COURSES

The steadily increasing number of listings in the DIGEST section on short courses indicates a formalization of continuing education for technically trained individuals in industrial and governmental facilities. Previously engineers and technicians learned new techniques and their application on the job and during their spare time.

The advent of a variety of engineering seminars and courses aimed at specific problem areas has increased the efficiency of technical training. Now an inexperienced engineer or technician can not only learn but also practice old and new techniques from experienced instructors. And most seminars and courses feature as speakers engineers who have had many years of experience in their fields.

Seminars and courses are sponsored by such organizations as universities, societies, and both profit and not-for-profit corporations. Highly qualified individuals have even sponsored some events. As a result, education and training that were once almost exclusively the domain of universities and colleges are available from other sources. It is thus important that the individual considering attendance at a seminar or course potential thoroughly check the content of the course or seminar prior to registration. Course content varies not only in technical areas but also in depth of presentation and application. Advertising brochures often fail to adequately describe the material to be presented.

One benefit often overlooked in seminars and courses is the chance for communication among engineers and technicians from a variety of industries who have similar problems. It is entirely possible that ideas exchanged could account for substantial cost savings in routine facility operation.

There are thus several benefits possible to registrants of short courses and seminars being offered. If your company has not yet utilized these sources of information and training, I recommend that you investigate them.

R.L.E.

EVALUATION AND CONTROL OF THE EXHAUST NOISE OF RECIPROCATING I.C. ENGINES

M.L. Munjal*

Abstract. ***The paper reviews recent advances in the analysis, design, and testing of exhaust mufflers for reciprocating internal combustion engines. An outline of specific areas needing further attention is given.***

Unmuffled exhaust noise of present-day internal combustion engines is at least 20 dB higher than almost any other engine noise; an exception is heavy-duty truck engines in which the engine noise is generally of the same order [1]. As has been noted [2, 3], most mufflers are of the reactive type -- also called reflective or nondissipative. They are so called because the absorbing materials such as fiberglass and steel wool deteriorate as a result of clogging, mechanical damage, or melting. Dissipative mufflers convert part of the acoustic energy to heat. A reactive muffler creates an impedance mismatch at the source so that much less acoustic power enters the muffler than would enter the exhaust pipe without the muffler. With an ideally reactive muffler, the acoustic power leaving the tail pipe would be equal to the power entering at the exhaust pipe inlet [4]. However, because of mean flow, aeroacoustic losses occur at area discontinuities in reactive mufflers.

This article describes various aspects of theoretical performance evaluation, experimental corroboration, and design of reactive mufflers.

MUFFLER PERFORMANCE CRITERIA

Several terms have been used to evaluate mufflers (see Figure 1). Dissipative mufflers are generally assessed in terms of attenuation, which is defined as the decrease in propagating sound power between two points in an acoustical system [5]. Reactive muffler performance is generally measured in terms of insertion loss (IL), transmission loss (TL), and noise reduction (NR). Noise reduction should be called level difference (LD), inasmuch as it is the difference in sound pressure level (SPL) measured upstream (at some point in the exhaust pipe) and downstream (at some point in the tail pipe); it is not the difference in acoustic power flux. Similarly, transmission loss is a misnomer for reactive mufflers because no loss in power flux occurs across reactive elements [4].

Insertion loss is convenient to measure and is often preferred by both manufacturers and users because it is a true measure of muffler performance. However, prediction of insertion loss requires measurement of, or prior knowledge of, the aeroacoustic characteristics (strength and internal impedance) of the engine exhaust system. Transmission loss and noise reduction are independent of source characteristics and are easy to predict but more difficult to measure. Prediction of NR requires prior knowledge of the radiation impedance; TL calls for non-reflective termination and is therefore more difficult to measure. TL and NR are used for research purposes; for example, to check transfer matrices or reflective properties of a set of elements in isolation.

MEASUREMENT OF REFLECTIVE PROPERTIES

There are a number of methods for measuring reflective properties of a termination or set of elements. The classical discrete frequency steady-state method -- also called the standing wave ratio (SWR) method -- can involve either locating acoustic pressure maxima and minima and drawing the acoustic envelopes through a traversing pressure probe [6-10], measuring SPL's at a number of discrete positions [11,12], or a combination [13] in which only the positions of minima (located precisely by a probe tube) and SPL's at a number of discrete points on

*Department of Mechanical Engineering, Indian Institute of Science, Bangalore 560 012, India

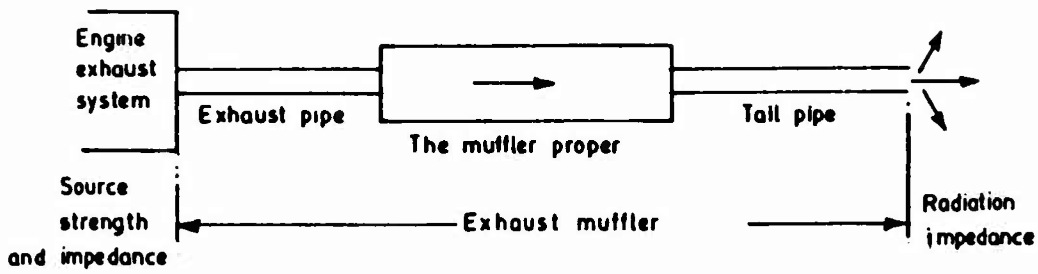

Figure 1. Conventional Terminology

the rising flank of a minimum are used. Panicker's method [13] is suited for exhaust mufflers in which mean flow introduces unsteadiness; as a result of unsteadiness the SPL measurements at the pressure minima are difficult and unreliable. Drawing and extrapolating the envelope of the minima to the plane of the termination under investigation are thus not possible. Schmidt and Johnson [14] used a discrete frequency technique in which two microphones were mounted at different upstream positions along a tube. They measured pressure amplitudes at the two points and deduced the reflection coefficient of the sample.

The method of transients involves the use of a sufficiently strong, small duration (less than a second) impulse to obtain the incident and reflected energies [15]. To and Doige [16, 17] successfully used a variation to determine matrix parameters of acoustic systems. Their method uses Fourier transforms of signals simultaneously picked up from two microphones and recorded on a tape recorder. Unfortunately, the method has not been tested for moving media.

Seybert and Ross [18] developed a two-microphone, random-excitation method in which the acoustic properties of the termination are recovered from auto- and cross spectra of microphone signals. The method incorporates mean flow effects but has been tried only with stationary media. Continuous sampling of data for seven seconds was sufficient. Chung and Blaser [19] have presented a modification. Instead of considering individual spectral densities, they use the transfer function between the signals sensed by the two microphones located upstream of the termination, neglecting attenuation between microphone signals. The expressions for impedance are thus greatly simplified, but the results presented are for a stationary medium. Singh and Soedel [20] used random and transient inputs to measure impedances of fluid machinery manifolds. Prasad [21] used Chung and Blaser's approach to measure engine impedance with the engine running.

The transient and random-excitation methods are much faster than the discrete frequency method but require two-channel FFT analysis instrumentation. In addition, in the presence of flow the signal to noise ratio may not be sufficiently high over the complete frequency range of interest. Until these methods are proved with moving media, the discrete frequency method [13] could remain the most reliable method, albeit a time-consuming one, for measuring the acoustic properties of a termination.

ACOUSTICAL APPROACH TO MUFFLER PERFORMANCE PREDICTION

Mathematical representation of the insertion loss of a muffler in terms of terminal impedances (radiation and source) and a velocity ratio that can be evaluated from successive multiplication of transfer matrices of all constituent elements has been presented [2]. The significant developments that have since taken place are described in the following paragraphs.

El-Sharkawy and Nayfeh [22] took all modes into account in an analysis of sound propagation through a circular duct in the presence of an expansion chamber. Their analysis was in good agreement with experiments. They showed that plane wave theory is valid only at low frequencies, small expansion ratios, and large expansion chamber length/diameter ratios. Unfortunately, even though mean flow was not considered, their expressions were very complicated.

The attenuation constant α for a progressive plane wave in a tube can be measured by means of the impedance-tube method -- also called the discrete frequency excitation method [13]; it is very difficult, however, to measure $\alpha_{\pm}$ for a tube with mean flow in the + direction. Based on other work [23, 24] Panicker [13] derived a general one-dimensional convected wave equation that incorporates the effects visco-thermal damping. He obtained (for $M^2 \ll 1$)

$$\alpha_{\pm}(M) = \frac{\alpha + \frac{FM}{2D}}{1 \pm M} \qquad (1)$$

M is the average mean-flow mach number in a tube of internal diameter D, α is the attenuation in a tube with stationary medium, F is the Froude's friction factor, for steady turbulent flow, and subscripts + and - denote the forward (positive) and the backward (negative) directions.

Equation (1) shows that mean flow has both a convective effect, represented by the denominator $1 \pm M$ and an effect on the viscous attenuation α; mean flow increases attenuation by an eddy viscosity term FM/2D. Although these visco-thermal attenuation constants play only a minor role in the transfer matrices of tubes, they are crucial for evaluating acoustic characteristics of a termination using the discrete frequency excitation impedance-tube method.

The radiation impedance for an unflanged pipe in the presence of mean flow

$$Z_0(M) = R_0(M) + jX_0(M) \qquad (2)$$

has been measured [13] for different tube sizes and frequencies. Experiments indicate that

$$R_0(M) \simeq R - 2M^2 \qquad (3)$$

$$X_0(M) \simeq X/(1 - M^2) \qquad (4)$$

The plots of these results are generally in agreement with those of others [25, 26]. The change in radiation impedance can be attributed to the fact that interaction of the outgoing wave and the jet absorbs a substantial part of the wave and exerts a back reaction on it. Howe [27] has pointed out that the acoustic energy that excapes from the tail pipe is partitioned between two distinct disturbances in the exterior fluid. The first disturbance is free-space radiation. Essentially compressible vortex waves are then excited by vortex shedding from the tail pipe lip and might be associated with large scale instabilities of the jet. There have been further attempts to model Helmholtz-type resonators in the presence of mean flow. Anderson [28] found that the fundamental frequency increased with increasing flow velocities in the duct, higher resonance frequencies of the resonator were not affected as much by air flow. He observed that it was possible for the entire mass end-correction of the orifice of the resonator to be eliminated by the flow. Qualitatively similar results had been obtained earlier [29, 30]; it was also found that the resistive part of the radiation impedance increases considerably because of mean flow.

Sullivan and Crocker [3] modeled multi-hole concentric tube resonators of the unpartitioned type, they accounted for mean flow in the tube, wave motion in the cavity, and coupling between cavity and tube via the impedance boundary of the perforate. They obtained good agreement with experiments for stationary medium, no experiments were reported with mean flow. Their results verified earlier observations [28-30] that grazing flow causes the resistance of the orifice to increase and the reactance to decrease with increasing flow rate.

Sullivan [32] has developed a segment procedure -- in which each segment is described by a transfer matrix -- for modeling such perforated muffler components as concentric resonators with perforated flow tubes and expansion chambers and reverse flow chambers with perforated inlet and outlet tubes (see Figure 2). The theory takes mean flow into account. However, the method is confined to those configurations having one acoustically long dimension. This approach thus leads to 4x4 or 6x6 transfer matrices that are more difficult to handle than conventional 2x2 matrices, but are simpler and faster than simultaneous solution of a very large number of

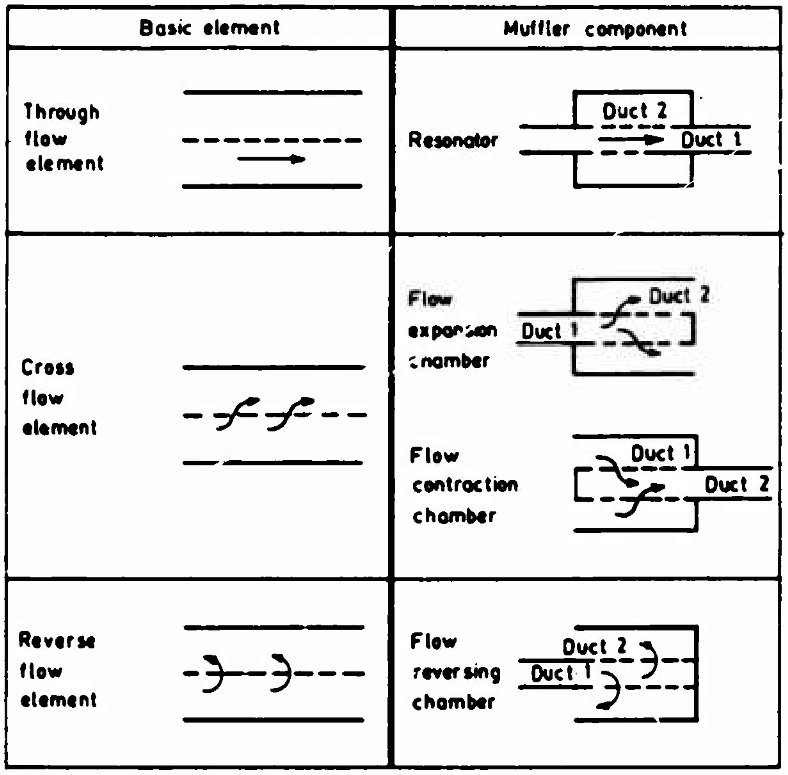

Figure 2. Basic Elements and Corresponding Muffler Components of Two-Duct Model [32]

algebraic equations. The theory has been used [33] to demonstrate the effect of nonlinear impedance of the perforation due to finite amplitude sound pressure in a straight-through resonator. The effect of change in impedance of the perforation with mean flow in a cross-flow chamber has also been shown. The impedance was that used in earlier measurements. Good agreement was found between theory and experimental observations with regard to transmission loss.

Interestingly, investigations [28-33] did not yield any general empirical formula for the resistive and reactive impedance of a hole in the presence of a grazing flow, which (or the linear part of which) could be used with the acoustical approach.

Transfer matrices have been recognized as handy building blocks in the analysis of one-dimensional acoustic filters [34] as well as for typical exhaust mufflers [21, 24, 32, 35, 36].

Panicker [13] derived transfer matrices defined with respect to convective state variables p_c and v_c, proposed by Munjal [36], for area discontinuities of the simple type shown in Figure 3a and 3b, the extended-tube type shown in Figure 3c and 3d, and the flow-reversal type shown in Figure 3e and 3f. He used the mass continuity equation, the energy equation involving a dissipation parameter, the momentum equation [37]. An additional equation determines the dissipation parameter in terms of the measured head loss coefficient for steady incompressible flow as a fraction of the dynamic head in the smaller diameter tube at the junction. The resultant transfer matrices are shown below.

Simple contraction, see Figure 3a.

$$\begin{bmatrix} 1 & K_c M_n Y_n \\ 0 & 1 \end{bmatrix} \qquad (5)$$

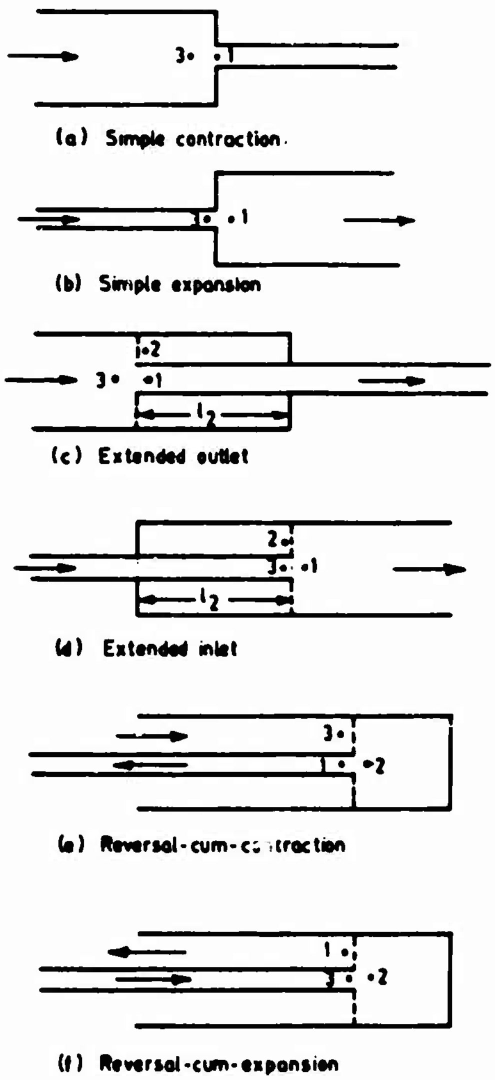

Figure 3. Acoustic Elements Involving Area Discontinuities

Simple expansion, see Figure 3b.

$$\begin{bmatrix} 1 & K_e M_n Y_n \\ 0 & 1 \end{bmatrix} \tag{6}$$

Extended outlet, see Figure 3c.

$$\begin{bmatrix} 1 & K_c M_n Y_n \\ \dfrac{1-N}{Z_2\,(1-N-AN^2)} & \dfrac{1-N+A(K_c-N)}{1-N-AN^2} \end{bmatrix} \tag{7}$$

Extended inlet, see Figure 3d.

$$\frac{1}{1-N+AN(1+K_e)} \begin{bmatrix} 1-N+A(N+K_e) & K_e M_n Y_n (1-N+AN^2) \\ \dfrac{1-N}{Z_2} & 1-N+AN^2 \end{bmatrix} \tag{8}$$

Reversal-cum-contraction

$$\begin{bmatrix} 1 & K_{rc} M_n Y_n \\ \dfrac{1+N}{Z_2\,(N_{2,b}-AN^2)} & \dfrac{N_{2,n}+A(N+K_{rc})}{N_{2,b}-AN^2} \end{bmatrix} \tag{9}$$

Reversal-cum-expansion

$$\frac{1}{N_{2,b}-AN(1+K_{re})} \begin{bmatrix} N_{2,b}+A(K_{re}-N) & K_{re} M_n Y_n (N_{2,b}+AN^2) \\ \dfrac{1+N}{Z_2} & N_{2,b}+AN^2 \end{bmatrix} \tag{10}$$

In the matrices

M = mean flow Mach number averaged over the cross-section area S (11)

Y = c/S

N = narrower tube area/broader tube area, $S_n/S_b = S_1/S_3$ or S_3/S_1

subscript n = pertaining to the narrower tube

subscript b - pertaining to the broader tube

Z_2 = equivalent impedance of the annular cavity

$$\simeq -j\,Y_2 \cot(k l_2) \tag{12}$$

$$K_c \simeq \frac{1-N}{2} \tag{13}$$

$$K_e \simeq (1-N)^2 \tag{14}$$

$$N_{2,b} = S_2/S_b \tag{15}$$

$$A = \frac{M_n Y_n}{Z_2} \tag{16}$$

$$K_{rc} \simeq \frac{1-N}{2} \text{ for } N < 0.2 \tag{17}$$

$$K_{re} \simeq 1 \tag{18}$$

Noise reduction (level difference) has been calculated for typical mufflers using these elements and radiation impedance -- Equation (3) and Equation (4) -- as well as a transfer matrix for a tube [36] incorporating the attenuation. The constant of Equation (1) agrees well with experimentally observed values [13].

Insertion loss, the most acceptable performance criterion, involves, in addition to radiation impedance and transfer matrices of the muffler elements, a prior knowledge of source impedance Z_s. Prediction of SPL at a point in space with a particular muffler also requires knowledge of source strength. This source strength can be acoustic pressure p_s, acoustic mass velocity v_s, or the corresponding convective (or aeroacoustic) counterparts $p_{c,s}$ or $v_{c,s}$. The value depends on the way the source is to be characterized [2, 3, 36, 38]. An indirect method -- also called a three-load method [3, 38] -- has been proposed [39-41]. It makes use of the impedance tube approach, measurement of radiated noise levels, or the numerical prediction approach. Precise measurements are needed but are difficult to obtain because of mean flow unsteadiness and slight but inevitable variations in the instantaneous speed of the reciprocating machinery. The impedance tube has been used with the two-microphone random-excitation technique to directly measure the acoustic impedance of a running I.C. engine [21, 42, 43]. It is assumed that impedance tube technology can be used to determine the impedance of an active termination directly so long as the external excitation signal is much stronger than the signal from the termination everywhere in the tube. Apart from the questionable character of this assumption, the method is very difficult to apply in view of unsteadiness and the resultant ambient noise due to turbulent mean flow. Incidentally, there have been few attempts thus far to predict engine exhaust source characteristics analytically.

GAS-DYNAMIC MODELING OF EXHAUST SYSTEMS

A number of developments have been reported in modeling exhaust systems of reciprocating compressors [44-46] and reciprocating I.C. engines [47] in terms of mass continuity equations, thermodynamic equations, and equations of momentum for different volumes and across various junctions. The muffler elements can be modeled in terms of acoustic variables [44, 46] or, more precisely, in terms of Riemann variables [39, 40, 48-50].

A substantially different approach involves finite elements [51-53]. This approach is applicable to many muffler configurations and accounts for three-dimensional effects, but it is also cumbersome and has not yet been tried with mean flow.

DESIGN OF EXHAUST MUFFLERS

Eriksson [54] has listed basic design considerations; they include minimum noise level, maximum engine performance, minimum weight, minimum size, minimum cost, long life, good tonal quality, manufacturing ease, convenient shape, minimum temperature, and attractive appearance. Munjal [55] used the algebraic algorithm to derive some general synthesis criteria for one-dimensional acoustic filters. These criteria were later extended to straight-through exhaust mufflers [24], a modified form of the algorithm was used to account for the convective effect of mean flow. Transfer matrices of different elements constituting expansion chamber mufflers have been used to develop a computer program for designing a muffler for a helicopter engine [35].

Davies [57] observed a complex interaction between the traveling vortex potential field, the sound field, and the tail pipe resonance at intermediate levels of forcing; the interaction resulted in additional noise generation at area expansions but could be effectively suppressed by fitting perforated bridges as illustrated in Figure 4.

Laville and Soedel [38] sought some scaling laws with a view to deriving empirical formulas in terms of certain nondimensional parameters for predicting muffler performance and thus muffler design. Blair [59] has developed general computer programs using

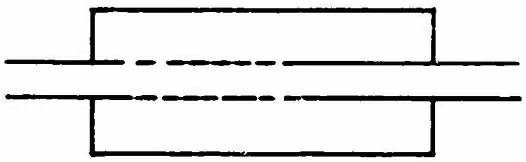

Figure 4. Suppression of Flow-Acoustic Coupling by a Bridge Perforate [57]

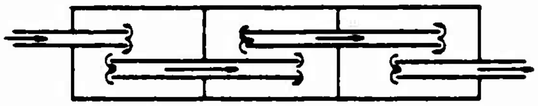

Figure 5. A Generally Successful Configuration for Single Cylinder Two-Stroke-Cycle Engines

finite-wave pulse analysis in the exhaust, intake, and transfer passages. He designed a small two-stroke engine for low specific fuel consumption and low exhaust noise levels. He used exhaust mufflers of the type shown in Figure 5. Incidentally, the same type of mufflers were found to be very satisfactory for single-cylinder two-stroke-cycle engines of autorickshas in India [60].

CONCLUDING REMARKS

Notable advances have been made in recent years in the analysis and design of exhaust mufflers. The gas-dynamic approach and its various ramifications can be used to analyze a given exhaust system. However, because of the computer time and effort required, the approach is largely ineffective for synthesis of an efficient configuration; at best, it might be useful for a final optimization.

The acoustical, or aeroacoustical, approach is more handy in analysis and potentially useful for design. However, elements involving hole-to-hole transfer of mean flow (Figure 2) need further attention. Analytical models for source characterization are necessary; direct measurement of the impedance of an active termination is questionable. Three-dimensional effects in the presence of not-so-uniform mean flow require furthr research for high-frequency analysis. Acoustic impedance of a hole or set of holes in the presence of grazing flow and/or through flow calls for empirical expressions.

For two-stroke-cycle engines, muffler performance is coupled to engine performance. Thus, exhaust stroke analysis cannot be isolated from the analysis of the rest of the cycle. However, there is a need to look for some practical short cuts, lest the muffler design become uneconomical.

Finally, the noise radiated from the outer shell of the muffler should be analyzed so that aeroacoustically predicted muffler performance could be realized without making the muffler unnecessarily heavy and costly.

REFERENCES

1. Hillquist, R.K. and Scott, W.N., "Motor Vehicle Noise Spectra: Their Characteristics and Dependence upon Operating Parameters," J. Acoust. Soc. Amer., 58 (1), pp 1-10 (1975).

2. Munjal, M.L., "Exhaust Noise and Its Control - A Review," Shock Vib. Dig., 9 (8), pp 21-32 (Aug 1977).

3. Crocker, M.J., "Internal Combustion Engine Exhaust Muffling," Noise-Con '77, pp 331-358 (1977).

4. Munjal, M.L., "A New Look at the Performance of Reflective Exhaust Mufflers," DAGA '80, München (Mar 1980).

5. Embleton, T.F.W., "Mufflers," in Noise and Vibration Control, L.L. Beranek, ed., McGraw-Hill (1971).

6. Beranek, L.L., Acoustic Measurements, John Wiley and Sons (1949).

7. Lippert, W.K.R., "The Practical Representation of Standing Waves in Acoustic Impedance Tube," Acustica, 3, pp 153-160 (1953).

8. "Impedance and Absorption of Acoustic Material by the Tube Method - reapproved," ASTM C 384-58 (1972).

9. Kathuriya, M.L. and Munjal, M.L., "An Accurate Method for the Experimental Evaluation of the Acoustical Impedance of a Black Box," J. Acoust. Soc. Amer., 58 (2), pp 451-454 (1975).

10. Kathuriya, M.L. and Munjal, M.L., "A Method for the Experimental Evaluation of the Acoustic Characteristics of an Engine Exhaust System in the Presence of Mean Flow," J. Acoust. Soc. Amer., 60 (3), pp 745-751 (1976).

11. Kathuriya, M.L. and Munjal, M.L., "Measurement of the Acoustic Impedance of a Black Box at Low Frequencies Using a Shorter Impedance Tube," J. Acoust. Soc. Amer., 62 (3), pp 751-754.

12. Kathuriya, M.L. and Munjal, M.L., "A Method for the Evaluation of the Acoustic Impedance of a Black Box with or without Mean Flow Measuring Pressures at Fixed Positions," J. Acoust. Soc. Amer., 62 (3), pp 755-759 (1977).

13. Panicker, V.B., "Some Studies on the Prediction and Verification of the Aeroacoustic Performance of Exhaust Mufflers," Ph.D. Thesis, Indian Inst. Sci., Bangalore (July 1979).

14. Schmidt, W.E. and Johnson, J.P., "Measurement of Acoustic Reflection from Destructions in a Pipe with Flow," NSF Rep. PD-20 (1975).

15. Gatley, W.S. and Cohen, R., "Methods for Evaluating the Performance of Small Acoustic Filters," J. Acoust. Soc. Amer., 46 (1), pp 6-16 (1969).

16. To, C.W.S. and Doige, A.G., "A Transient Testing Technique for the Determination of Matrix Parameters of Acoustic Systems; I, Theory and Principles," J. Sound Vib., 62 (2), pp 207-222 (1979).

17. To, C.W.S. and Doige, A.G., "A Transient Testing Technique for the Determination of Matrix Parameters of Acoustic Systems, II, Experimental Procedures and Results," J. Sound Vib., 62 (2), pp 223-233 (1979).

18. Seybert, A.F. and Ross, D.F., "Experimental Determination of Acoustic Properties Using a Two-Microphone Random-Excitation Technique," J. Acoust. Soc. Amer., 61 (5), pp 1362-1370 (1977).

19. Chung, J.Y. and Blaser, D.A., "A New Method of Measuring In-Duct Acoustic Properties; I: Theory; II: Experiment," GMR-3167 and GMR-3168, General Motor Res. Lab. (1979).

20. Singh, R. and Soedel, W., "An Efficient Method for Measuring Impedances of Fluid Machinery Manifolds," J. Sound Vib., 56 (1), pp 105-125 (1978).

21. Prasad, M.G., "Acoustical Modelling of Automotive Exhaust Systems," Ph.D. Thesis, Purdue Univ. (Aug 1980).

22. El-Sharkawy, A.I. and Nayfeh, A.H., "Effect of an Expansion Chamber on the Propagation of Sound in Circular Ducts," J. Acoust. Soc. Amer., 63 (3), pp 667-675 (1978).

23. Rschevkin, S.N., A Course of Lectures on the Theory of Sound, McMillan and Co. (1963).

24. Thawani, P.T., "Analytical and Experimental Investigation of the Performance of Exhaust Mufflers with Flow," Ph.D. Thesis, Univ. of Calgary (1978).

25. Alfredson, R.J. and Davies, P.O.A.L., "The Radiation of Sound from an Engine Exhaust," J. Sound Vib., 13 (4), pp 389-408 (1970).

26. Ingard, U. and Singhal, U.K., "Sound Attenuation in Turbulent Pipe Flow," J. Acoust. Soc. Amer., 55 (3), pp 535-538 (1974).

27. Howe, M.S., "Attenuation of Sound in a Low Mach Number Nozzle Flow," J. Fluid Mech., 91, pp 209-230 (1979).

28. Anderson, J.S., "The Effect of Airflow on a Single Side-Branch Helmholtz Resonator in a Circular Duct," J. Sound Vib., 52 (3), pp 423-431 (1977).

29. Ronneberger, D., "The Acoustic Impedance of Holes in the Wall of Flow Ducts," J. Sound Vib., 26 (1), pp 133-150 (1972).

30. Hirata, Y. and Itow, T., "Influence of Air Flow on the Attenuation Characteristics of Resonator-Type Mufflers," Acustica, 28, pp 115-120 (1973).

31. Sullivan, J.W. and Crocker, M.J., "Analysis of Concentric Tube Resonators Having Unpartitioned Cavities," J. Acoust. Soc. Amer., 64, pp 207-215 (1978).

32. Sullivan, J.W., "A Method for Modelling Perforated Tube Muffler Components, I: Theory," J. Acoust. Soc. Amer., 66 (3), pp 772-778 (1979).

33. Sullivan, J.W., "A Method for Modelling Perforated Tube Muffler Components, II: Applications," J. Acoust. Soc. Amer., 66 (3), pp 779 788 (1979).

34. Munjal, M.L., Sreenath, A.V., and Narasimhan, M.V., "Velocity Ratio in the Analysis of Linear Dynamical Systems," J. Sound Vib., 26 (2), pp 173-191 (1973).

35. Parrott, T.L., "An Improved Method for Design of Expansion Chamber Mufflers with Application to an Operational Helicopter," NASA TN D-7309 (Oct 1973).

36. Munjal, M.L., "Velocity Ratio-cum-Transfer Matrix Method for the Evaluation of a Muffler with Mean Flow," J. Sound Vib., 39 (1), pp 105-119 (1975).

37. Alfredson, R.J. and Davies, P.O.A.L., "Performance of Exhaust Silencer Components," J. Sound Vib., 15 (2), pp 175-196 (1971).

38. Sullivan, J.W., "Modelling of Engine Exhaust System Noise," Noise Fluids Engr., Ann. Mtg. ASME, pp 161-170 (Nov/Dec 1977).

39. Munjal, M.L. and Kathuriya, M.L., "Acoustic Characterization of an Engine Exhaust System," Proc. Third Natl. Conf. I.C. Engines Combustion, Roorkee, pp 201-210 (Dec 1976).

40. Kathuriya, M.L. and Munjal, M.L., "Prediction of Noise of an Engine Exhaust System," Proc. Fourth Natl. Conf. I.C. Engines Combustion, Madras, pp E1-61-70 (Dec 1977).

41. Kathuriya, M.L. and Munjal, M.L., "Experimental Evaluation of the Aeroacoustic Characteristics of Source of Pulsating Gas Flow," J. Acoust. Soc. Amer., 65 (1), pp 240-249 (1979).

42. Galaitsis, A.G. and Bender, E.K., "Measurement of the Acoustic Impedance of an Internal Combustion Engine," J. Acoust. Soc. Amer., 58 (Supp. No. 1) (Fall 1975).

43. Ross, D.F., Crocker, M.J., and Sullivan, J.W., "Determination of Normal Specific Acoustic Impedance Using a Random Signal," Ray W. Herrick Labs. Internal Rep. HL 75-45 (Dec 1975).

44. Singh, R. and Soedel, W., "Assessment of Fluid Induced Damping in Refrigeration Machinery Manifolds," J. Sound Vib., 57, pp 449-452 (1978).

45. Singh, R. and Soedel, W., "Mathematical Modelling of Multi-Cylinder Compressor Discharge System Interactions,' J. Sound Vib., 63, pp 125-143 (1979).

46. Singh, R. and Soedel, W., "Interpretation of Gas Oscillations in Multicylinder Fluid Machinery Manifolds by Using Lumped Parameter Descriptions," J. Sound Vib., 64 (3), pp 387-402 (1979).

47. Mutyala, B.R.C. and Soedel, W., "A Mathematical Model of Helmholtz Resonator Type Gas Oscillation Discharges of Two-Stroke Cycle Engines," J. Sound Vib., 44 (4), pp 479-491 (1976).

48. Coates, S.W. and Blair, G.P., "Further Studies of Noise Characteristics of Internal Combustion Engine Exhaust Systems," SAE, 83 (740713) (1974).

49. Blair, G.P. and Ashe, M.C., "The Unsteady Gas-Exchange Characteristics of a Two-Cycle Engine," SAE Trans. 760644 (1976).

50. Lakshminarayanan, P.A., Janakiraman, and Babu, M.K.G., "A Finite Difference Scheme for Unsteady Pipe Flows," Intl. J. Mech. Sci., (GB) 21 (9), p 557 (1979).

51. Young, C.I.J. and Crocker, M.J., "Prediction of Transmission Loss in Mufflers by the Finite-Element Method," J. Acoust. Soc. Amer., 57 (1), pp 144-148 (1975).

52. Kagawa, Y. and Omote, T., "Finite Element Simulation of Acoustic Filters of Arbitrary Profile with Circular Cross-section," J. Acoust. Soc. Amer., 60 (5), pp 1003-1013 (1976).

53. Craggs, A., "A Finite Element Method for Damped Acoustic Systems: An Application to Evaluate the Performance of Reactive Mufflers," J. Sound Vib., 48 (3), pp 377-392 (1976).

54. Eriksson, L.J., "Current Alternatives in Exhaust System Acoustical Evaluation," S/V Sound Vib., pp 18-25 (1978).

55. Munjal, M.L., Sreenath, A.V., and Narasimhan, M.V., "An Algebraic Algorithm for the Design and Analysis of Linear Dynamical Systems," 26 (2), pp 193-208 (1973).

56. Munjal, M.L., Narasimhan, M.V., and Sreenath, A.V., "A Rational Approach to the Synthesis of One-Dimensional Acoustic Filters," J. Sound Vib., 29 (3), pp 263-280 (1973).

57. Davies, P.O.A.L., "Bench Test Procedures and Exhaust System Performance Prediction," EPA Proc. Surface Transportation Exhaust Syst. Noise, pp 5-48 (1977).

58. Laville, F. and Soedel, W., "Some New Scaling Rules for Use in Muffler Design," J. Sound Vib., 60 (2), pp 273-288 (1978).

59. Blair, G.P., "Computer-Aided Design of Small Two-Stroke Engines for Both Performance Characteristics and Noise Levels," Instn. Mech. Engr. Proc., C 120/78, pp 51-69 (1978).

60. Munjal, M.L. and Narayanaswamy, K., "Silencers for Autorickshas," Final Rep. KSCST Project, Indian Inst. Sci., Bangalore (Nov 1977).

LITERATURE REVIEW: survey and analysis of the Shock and Vibration literature

The monthly Literature Review, a subjective critique and summary of the literature, consists of two to four review articles each month, 3,000 to 4,000 words in length. The purpose of this section is to present a "digest" of literature over a period of three years. Planned by the Technical Editor, this section provides the DIGEST reader with up-to-date insights into current technology in more than 150 topic areas. Review articles include technical information from articles, reports, and unpublished proceedings. Each article also contains a minor tutorial of the technical area under discussion, a survey and evaluation of the new literature, and recommendations. Review articles are written by experts in the shock and vibration field.

This issue of the DIGEST contains articles about vibration control with viscoelastic materials and vibrations and stability of mechanical systems.

Professor B.C. Nakra of the Indian Institute of Technology, Hauz Khas, New Delhi has written a paper reviewing investigations dealing with vibration control using viscoelastic materials. Specific topics include analysis of configurations, properties of the materials used, and applications.

Professor K. Huseyin of the University of Waterloo, Waterloo, Ontario, Canada has written an article describing developments in linear and nonlinear theories for studying the vibrational and stability behavior of autonomous systems under the influence of several independent parameters.

VIBRATION CONTROL WITH VISCOELASTIC MATERIALS - II

B.C. Nakra*

Abstract. This paper reviews investigations dealing with vibration control using viscoelastic materials. Specific topics include analysis of configurations, properties of the materials used, and applications.

In an earlier paper [32], work on control of vibrations using viscoelastic materials in various arrangements was reviewed. These materials usually have high damping and thus dissipate vibratory energy of structures and machines. The present paper reviews some further work on the role of viscoelastic materials in vibration control: the analysis of configurations of viscoelastic materials, properties of materials used, and applications reported in the recent literature.

ANALYSIS

Theoretical analyses of flexural vibrations of multilayered beams, plates, and shells, employing various arrangements of elastic and viscoelastic layers, have been reviewed extensively [32]. Other work on this topic deals with the flexural vibrations of laminated, hollow, and circular beams [3]. It has been reported that vibration damping is not significant in modes in which elastic beams move together, but that for higher modes, in which elastic beams move in opposite directions, high damping is obtained.

Rao [42, 43] has published work on short simply supported sandwich beams having a viscoelastic core and various boundary condition cases. He used digital computer simulation to solve the differential equations of motion. Sandman [45] dealt with flexural steady-state forced vibrations of sandwich beams with nonuniform distribution of shearing rigidity and mass along the core length; he suggested that a tuned configuration of core segments would provide optimum damping. Analysis of nonlinear vibrations due to large deformations of three-layer beams with viscoelastic cores has been reported [13, 21]. Viscoelastically damped beams, subjected to shock excitation, have been analyzed [18-20]; the differential operator representation was used for viscoelastic materials.

Five-layered beams with viscoelastic layers have been analyzed [6, 31], as have Timoshenko beams with five stiff and four soft layers placed on an elastic foundation and subjected to a concentrated point load moving with a constant velocity [40]. Vibration damping analysis of a three-layered plate with viscoelastic core has been carried out [4, 28, 29, 44]. Mead [28] determined resonant frequencies and loss factors of three-layered damped sandwich plates with regularly spaced stiffeners. Finite element analyses of multilayered structures containing viscoelastic materials have been reported [37, 38].

Vibration damping in cylindrical elastic shells, coated with layers of viscoelastic materials, has been analyzed [16, 25, 26]. Hayari and Sandman [8] analyzed the vibratory response of three-layered cylindrical shells embedded in a fluid.

The effect of fluid mass loading and damping has been studied. Forced vibration analysis of liquid-filled cylindrical shells with a number of mass segments adhered to them externally by a viscoelastic material has been carried out [23], the excitation was due to a radial force acting on the surface of the shell. Lu [22] also analyzed the forced vibrations of thin rings having discrete mass segments and attached to the outer circumference by a viscoelastic material. Almy and Nelson [1] have reported work on the damping of a circular ring segment due to a constraining layer.

Theoretical work has also been reported on the torsional vibration analysis of two-layer beams [14] and

*Professor, Mechanical Engineering Department, Indian Institute of Technology, Hauz Khas, New Delhi - 110029, India

composite shafts having a viscoelastic core [2]. Sainbury and Ewins [46] have used impedance methods to analyze the vibration isolation characteristics of a two-stage multi-directional vibration isolation system. They used rubber blocks with five-layered damped sandwich beams for vibration isolation. A two stage isolation system, consisting of a conventional isolator and a three-layered damped sandwich beam, was analyzed [50]. Vaicaitis [49] analyzed low-frequency noise transmission by viscoelastic sandwich panels into a rectangular enclosure and reported that noise was significantly reduced.

MATERIALS AND PROPERTIES

Viscoelastic materials for vibration control have been discussed [11, 41]. Wetton [51] gave design requirements from the point of view of a chemist. Several formulations of viscoelastic materials have been considered. Earlier work on measuring properties of viscoelastic materials has been reviewed [32]. A number of methods for measuring dynamic stiffness and damping properties of viscoelastic materials have been discussed [10]. A number of methods have been given for measuring damping properties of thin coatings at high temperatures [34, 48]. Murayama [30] recently described in detail the principles of dynamic measurements of properties of viscoelastic materials and interpretation of data on a molecular basis.

APPLICATIONS

Various applications of viscoelastic materials for vibration control have been reviewed [32]. Additional work is reviewed in this section.

Attempts to adapt tuned dampers made of viscoelastic materials to gas turbine blades [33, 36] and machine tools [35] have been reported. Grooten-Luis [7] used the constrained layer damping technique to reduce noise and vibration disturbances caused by a railway through a residential area. Constrained layers have been used as dampers on the spindle of a textile spinning frame and on circular wood cutting saw blades [5]. Viscoelastic damping techniques have been extensively employed in jet engines, helicopters, spacecraft, and satellites [9, 12, 15, 24, 39]. General applications have been reviewed [27], as has work on control of low-frequency interior noise in aircraft by damping of fuselage structural elements with constrained damping on stringers [47].

REFERENCES

1. Almy, C.R. and Nelson, F.C., "Damping of a Circular Ring Segment by a Constraining Layer," Shock Vib. Bull., U.S. Naval Res. Lab., Proc., No. 42, Pt. 4, pp 121-124 (1972).

2. Chandrasekharan, M.P. and Ghosh, A., "Damping Characteristics of Elastic-Viscoelastic Composite Shafts," J. Sound Vib., 37 (1), pp 1-15 (1974).

3. DiTaranto, R.A., "Lateral Vibrations of a Damped Laminated Hollow Circular Cross-section Beam," J. Engr. Indus., Trans. ASME, 96, pp 845-852 (1974).

4. Durocher, L.L. and Solecki, R., "Harmonic Vibrations of Isotropic, Elastic and Elastic/Viscoelastic Three Layered Plates," J. Acoust. Soc. Amer., 60 (1), pp 105-112 (1976).

5. Emerson, P.D., "Application of Constrained Layer Damping to Control Noise in Machine Parts," J. Engr. Indus., Trans. ASME, 96, pp 299-303 (1974).

6. Frohrib, D.A., "Optimum Design of Five Ply Viscoelastic Isolation Fixture for Point Inertia Loading," Shock Vib. Bull., U.S. Naval Res. Lab., Proc., No. 38, Pt. 3, p 37 (1968).

7. Grootenhuis, P., "Floating Track Slab Isolation for Railways," J. Sound Vib., 51 (3), pp 443-448 (1977).

8. Harari, A. and Sandman, B.E., "Vibratory Response of Laminated Cylindrical Shells, Embedded in an Acoustic Fluid," J. Acoust. Soc. Amer., 60 (1), pp 117-128 (1976).

9. Henderson, J.P. et al, "Investigation of Effect of Damping Treatment on Response of Heated Fuselage Structures," Shock Vib. Bull., U.S. Naval Res. Lab., Proc., No. 45, Pt. 5 (1975).

10. Hillberry, B.M. (Ed.), "The Measurement of the Dynamic Properties of Elastomers and Elastomeric Mounts," Proc. SAE Intl. Auto. Engr. Congr., Detroit, MI (1973).

11. Hobaica, E.C. and Sweet, G., "Behaviour of Elastomeric Materials under Dynamic Loading," Shock Vib. Dig., 8 (3), pp 77-88 (1976).

12. Hobbs, G.K., Kuyper, D.J., and Brooks, J.J., "Response Analysis of a System with Discrete Dampers," Shock Vib. Bull., U.S. Naval Res. Lab., Proc., No. 46, Pt. 4, pp 137-152 (1976).

13. Hyer, M.W., Anderson, W.J., and Scott, R.A., "Non-linear Vibration of Three Layer Beams with Viscoelastic Core," J. Sound Vib., 46 (1), pp 121-136 (1976).

14. Johnson, A.F. and Woolf, A., "Dynamic Torsion of a Two Layer Viscoelastic Beam," J. Sound Vib., 48 (2), p 251 (1976).

15. Jones, D.I.G. et al, "Controlling Dynamic Response of Jet Engine Components," Shock Vib. Bull., U.S. Naval Res. Lab., Proc., No. 45, Pt. 5 (1975).

16. Kagawa, Y. and Krokstad, A., "On the Damping of Cylindrical Shells, Coated with Viscoelastic Materials," ASME Paper 69-Vibr-9, pp 1-9 (1969).

17. Kanovich, M.Z. and Koltunov, M.A., "Equations of Forced Vibrations for Viscoelastic Multilayer Plates," Polymer Mech., 13 (2), pp 312-314 (1977).

18. Kapur, A.D. and Nakra, B.C., "Performance of Viscoelastically Damped Multilayer Structures, Subjected to Shock Excitation," AIAA J., 15, pp 129-130 (1977).

19. Kapur, A.D., Nakra, B.C., and Chawla, D.R., "Shock Response of Viscoelastically Damped Beams," J. Sound Vib., 35 (3), pp 351-362 (1977).

20. Kapur, A.D. and Nakra, B.C., "Response of Sandwich Cantilever Beams to Shock Excitation," Strojnicky Casopis, 28 (1), pp 50-67 (1977).

21. Kovac, E.J., Anderson, W.J., and Scott, R.A., "Forced Nonlinear Vibrations of a Damped Sandwich Beam," J. Sound Vib., 17 (1), pp 25-39 (1971).

22. Lu, Y.P., "An Analytical Formulation of Forced Response of Damped Rings," J. Sound Vib., 48 (1), pp 27-33 (1976).

23. Lu, Y.P., "Forced Vibrations of Damped Cylindrical Shells Filled with Pressurised Liquid," AIAA J., 15 (9), pp 1242-1249 (1977).

24. McGuire, D.P., "The Application of Elastomeric Lead-Lag Dampers to Helicopter Rotors," Shock Vib. Bull., U.S. Naval Res. Lab., Proc., No. 46, Pt. 4, pp 153-162 (1976).

25. Markus, S., "Refined Theory of Damped Axisymmetric Vibrations of Double Layered Cylindrical Shells,' J. Mech. Engr. Sci., 21 (1), pp 33-37 (1979).

26. Markus, S., "Damping Properties of Layered Cylindrical Shells, Vibrating in Axially Symmetric Modes," J. Sound Vib., 48 (4), pp 511-524 (1976).

27. Martinant, J., "Structures Vibrations Decrease through Damping Increase," Revue Generale de Thermique, 15 (176/177), pp 761-783 (1976).

28. Mead, D.J., "Loss Factors and Resonant Frequencies of Periodic Damped Sandwich Plates," J. Engr. Indus., Trans. ASME, 98, pp 75-80 (1976).

29. Mukhopadhyay, A.K. and Kingsbury, H.B., "On the Dynamic Response of Rectangular Sandwich Plates with Viscoelastic Core and Generally Orthotropic Facings," J. Sound Vib., 47 (3), pp 347-358 (1976).

30. Muryarna, T., Dynamic Mechanical Analysis of Polymeric Materials, Elsevier Sci. Publ. (1978).

31. Nakra, B.C., ' Vibration Analysis of an Unsymmetrical Five Layer Beam, with Constrained Viscoelastic Layers," J. Acoust. Soc. India, 4, pp 45-54 (1976).

32. Nakra, B.C., "Vibration Control with Viscoelastic Materials," Shock Vib. Dig., 8 (6), pp 3-12 (1976).

33. Nashif, A.D., "Development of Practical Tuned Dampers to Operate over a Wide Temperature Range," Shock Vib. Bull., U.S. Naval Res. Lab., Proc., No. 38, Pt. 3, p 57 (1968).

34. Nashif, A.D., "Enamel Coatings for High Temperature Damping Materials," Bull. Amer. Ceramic Soc., 53 (12), p 846 (1974).

35. Nessler, G.L. et al, "Design of a Viscoelastic Dynamic Absorber for Machine Tool Applications," ASME Paper No. 76-WA/Prod-20 (1976).

36. Parin, M.L. and Jones, D.I.G., "Encapsulated Tuned Dampers for Jet Engine Component Vibration Control," J. Aircraft, 12 (4), pp 293-295 (1975).

37. Paulard, et al, "Response of Thick Structures Damped by Viscoelastic Materials, with Application to Layered Beams and Plates," Shock Vib. Bull., U.S. Naval Res. Lab., Proc., 45 (5), p 65 (1975).

38. Pedersen, F.B., "Vibration Analysis of Viscoelastically Damped Sandwich Structures," Rep. R 88, Tech. Res. Lab., Tech. Univ. Denmark (1978).

39. Poizat, M., Vialatoux, P., Cochery, P., and Vedrenne, M., "Viscoelastic Damping System Use as a Remedy for Pogo Effect on the Diamant Satellite Launch Vehicle," Shock Vib. Bull., U.S. Naval Res. Lab., Proc., No. 46, Pt. 2, pp 245-266 (1976).

40. Prasad, B. and Herrmann, G., "Response of a Laminated Beam to a Moving Load," AIAA J. 15 (10), pp 1424-1431 (1977).

41. Purcell, W.E "Materials for Noise and Vibration Control," Shock Vib. Dig., 10 (7), pp 6-33 (1976).

42. Rao, D.K., "Frequency and Loss Factors of Sandwich Beams, under Various Boundary Conditions," J. Mech. Engr. Sci., 20 (5), pp 271-282 (1978).

43. Rao, D.K., "Vibrations of Short Sandwich Beams,' J. Sound Vib., 52 (2), pp 253-263 (1977).

44. Rao, Y.V.K.S. and Nakra, B.C., "Theory of Vibratory Bending of Unsymmetrical Sandwich Plates," Arch. Mech., 25 (2), pp 213-225 (1973).

45. Sandman, B.E., "Flexural Vibrations of Segmented Elastic-Viscoelastic Sandwich Beams," J. Appl. Mech., Trans. ASME, 42 (4), pp 897-900 (1975).

46. Sainsbury, M.G. and Ewins, D.J., "Vibration Analysis of a Damped Machinery Foundation Structure, Using the Dynamic Stiffness Coupling Technique," J. Engr. Indus., Trans. ASME, 96, pp 1000-1005 (1974).

47. Sengupta, G., "Reduction of Cabin Noise and Vibration through Intrinsic Structural Tuning," AIAA J., 16, pp 545-546 (1978).

48. Sridharan, P. and Plunkett, R., "Equipment for Measuring Complex Modulus of Thin Coatings at Elevated Temperatures," J. Engr. Indus., Trans. ASME, 96, pp 969-975 (1974).

49. Vaicaitis, R., "Noise Transmission by Viscoelastic Sandwich Panels," NASA TN D-8516 (1977).

50. Vikal, R.C.D., Gupta, K.N., and Nakra, B.C., "Two Stage Isolation System Using Viscoelastic Materials," Proc. 21st ISTAM Congress (1976).

51. Wetton, R.E., "Design and Measurement of Polymeric Materials for Vibration Absorption and Control," Appl. Acoust., 11 (2), pp 77-98 (1978).

VIBRATIONS AND STABILITY OF MECHANICAL SYSTEMS : II

K. Huseyin*

Abstract - This article describes developments in linear and nonlinear theories for studying the vibrational and stability behavior of autonomous systems under the influence of several independent parameters. Four classes of systems are identified for linear theories: conservative, pseudo-conservative, gyroscopic, and circulatory. Nonlinear theories involve both gradient and nongradient systems.

Developments concerning the stability and instability behavior of finite-degree-of-freedom holonomic autonomous mechanical systems were reviewed in 1976 [1]; attention was focused on linear general theories. The 1976 review [1] included developments concerning the combined effects of independent parameters on the behavior of a system. The present review, essentially an extension of the 1976 article [1], covers the years since 1976, and should be considered in conjunction with the earlier article. The present review expands the scope of the earlier one to nonlinear developments as well as linear studies.

LINEAR THEORIES

A system is usually under the influence of several independent parameters, and it is often necessary to determine the effects of these parameters on free vibrations and stability behavior of the system. Stability can be lost from an initially stable state in different ways as the parameters are varied. Conditions causing loss of stability, the nature of instability, characteristic features of the stability boundary, the parameter-frequency relationship, and in nonlinear range post-critical behavior are basic questions to be explored in a general study.

A linear general theory concerning the free vibrations and stability of multiple-parameter autonomous systems is now available in book form [2]. Development of this theory relies on matrix theory, which is summarized; fundamental definitions, stability criteria, and a classification of systems are then given. Divergence instability and flutter instability, including the conditions under which these phenomena arise are explored; the effects of the multiplicity of characteristic roots and linear dependence of characteristic vectors on the stability of a critical state are examined.

Lyapunov's Theorems, their connection to Stein's Theorem, the Routh-Hurwitz criterion, Hamilton's principle, and Lagrange's equations are discussed. Four classes of systems are identified: conservative, pseudo-conservative, gyroscopic, and circulatory. It is shown that the fundamental characteristic surface and the stability boundary of conservative systems cannot have convexity toward the fundamental region. Practical implications of these theorems and a normality condition are discussed. Effects of damping on the system are explored, and certain bounds on the complex eigenvalues are established through the extremum properties of the Rayleigh Quotient.

Pseudo-conservative systems are defined, and several theorems concerning the properties of the stability boundary, parameter-frequency relationship, and upper and lower bound estimates are presented. The discussion of gyroscopic systems is sufficiently general to allow for reinterpretations of the results in other contexts. It is shown that gyroscopic conservative systems can exhibit both flutter and divergence; conditions leading to such behavior are explored, as are certain standard forms of the associated eigenvalue problems [3] and their analytical advantages. These standard forms are shown to fall within the scope of the Rayleigh Quotient.

The effects of external and internal damping on the flutter and divergence boundaries are given. Rotating systems and fluid-conveying pipes are treated as

*Department of Systems Design, University of Waterloo, Waterloo, Ontario, Canada N2L 3G1

special gyroscopic systems; examples of flexible rotating shafts under the influence of axial loads are provided. Earlier results [4] are generalized, the flutter boundary of the undamped system is shown to be an upper bound for the flutter boundary of the damped system.

Circulatory systems and follower type loads are distinguished from pseudo-conservative systems in that the latter are incapable of exhibiting flutter instability due to the weak asymmetry of the matrices associated with follower forces. The generalized Rayleigh Quotient associated with flutter instability is introduced, certain max-min properties for two-degree-of-freedom systems contrast with those of the classical Rayleigh Quotient. Flutter and divergence boundaries are convex toward the fundamental region rather than concave. A direct method of stability analysis yields the flutter load without requiring the determination of frequencies.

Linear systems have also been treated in [5], but external parameters and their effects on the behavior of the system were not considered explicitly. Rather, emphasis is on the interrelationship between the structures of the matrices involved and the stability of the system. Stability criteria for autonomous and nonautonomous systems are developed on the basis of controllability and observability as well as Lyapunov's theorems. Systems have been classified according to the properties of matrices; conditions for asymptotic stability, marginal stability, and instability are given.

A discussion of the stability of autonomous systems deals with the nonlinear post-critical behavior of gradient systems and with developments concerning conservative, pseudo-conservative, gyroscopic, and circulatory systems [6]. Necessary and sufficient conditions are given for uncoupled modes of vibration in a damped system; alternative necessary and sufficient conditions for asymptotic stability of autonomous systems, including gyroscopic systems with external and internal dissipation, are also presented.

Some recent work [7-9] has been devoted to a reexamination of the variational principles associated with nonconservative systems. A class of nonconservative systems that admits a pure Lagrangian is identified, the Lagrangian formulation thus contains no generalized forces to account for nonconservative effects. The Lagrangian is constructed explicitly and used to derive the equations of motion. Three kinds of time-independent exact bilinear Lagrangians that govern the motion of linear multiple-degree-of-freedom systems are derived by doubling the size of the original space with the help of the adjoint system [8]. It is observed, however, that when the Lagrangians are modified and expressed in terms of the physical sets of variable only, they are time dependent. The problem is linked to the inverse problem of calculus of variations and analytical dynamics; this problem has been brought up to date [10, 11].

Certain investigations [7, 8] have been motivated by studies [12, 13] into the methodology by which large-scale physical systems are so reduced as to retain the physical structure of the original system. These studies are based on Hamilton's canonical equations; such basic theories as contact transformations and the Hamilton-Jacobi theory are for the most part for conservative systems and require additional and more convenient generalizations. A variational principle for the stability analysis of discrete nongradient systems is also available [14].

The effect of damping on vibration and the stability of mechanical systems has also received renewed attention. Nicholson [15] considered a discrete damped conservative system with positive definite stiffness, damping, and mass matrices. He implied that the positive definiteness of mass and damping matrices together with a commutativity condition among the three matrices are both necessary and sufficient for asymptotic stability. Although these conditions may apply to systems with completely uncoupled motion, the positive definiteness of the damping matrix is generally a sufficient but not necessary condition for asymptotic stability [1, 2, 6], the case of pervasive damping with a positive semi-definite matrix is an example.

A necessary and sufficient condition for asymptotic stability when the damping matrix is positive semi-definite is that none of the eigenvectors of the corresponding nondissipative system lie in the null space of the damping matrix [2]. The conditions for asymptotic stability, marginal stability, and instability have been discussed [16]. Certain bounds on the frequency response of forced vibrations when the equations of the damped system can be uncoupled --

i.e., simultaneous diagonalization of the mass, damping, and stiffness matrices is possible -- were also derived [16]. These results sharpen those of Nicholson [17].

In a study of the eigenvalues for damped linear systems, Nicholson [18] obtained lower bounds on the real and imaginary parts of the eigenvalues of a damped linear system in free vibration under certain conditions. Muller [19] generalized his results by removing some of the conditions and developed improved bounds. A sufficient condition for subcritical damping in all modes is given.

Other discussions of the effect of damping on the vibration-stability relationship of linear systems [20] and the shape modes of damped systems are available [21]. The necessary and sufficient condition for uncoupling the equations of damped systems has been presented [22] as discussed earlier. The equations governing free and forced vibrations of a general nonconservative system have been explored [23, 24]; conclusions concerning the stability of a three-degree-of-freedom circulatory system have been derived [25]. The dynamic behavior of dissipative circulatory structural systems has been studied [26].

Attention [27] has been drawn to the important role of structural damping in reducing the response of a vibrating structural system. Independent damping for various members was also considered. A practical method for controlling response was suggested [27] vary the member damping values by constructing critical damping surfaces, thereby separating regions of partial or complete underdamping from those of overdamping. Damping can have a destabilizing effect on the behavior of pseudo-conservative systems[28]. The significance of this destabilization is that the behavior of an undamped pseudo-conservative system is completely analogous to that of a conservative system; the destabilization is an indication that the addition of dissipative forces may expose the inherently nonconservative characteristics of the system.

Other developments include an instability condition [29] for gyroscopic conservative systems with n degrees of freedom and a simplification [30] of the Routh procedure for eliminating ignorable coordinates when the rotors in a multi-body system are kept at constant relative angular velocity.

NONLINEAR THEORIES

General nonlinear theories concerning discrete autonomous systems have developed in two directions. In one line of research only gradient systems are considered; the second direction also involves nongradient systems and is more comprehensive. Well-established methods for the nonlinear analysis of critical, post-critical, and stability behavior of gradient systems are now available. In fact the behavior of gradient systems can be described by an all-embracing potential function (e.g., total potential energy of conservative systems) that provides a convenient basis for nonlinear analyses, particularly the development of general theories. Thus, following the pioneering work of Poincaré, the nonlinear instability behavior of discrete gradient systems under the influence of one [31] or several independent parameters [32] has been studied extensively. A more recent development in this area has been introduced as elementary catastrophes [33].

It is known that a gradient system under the influence of a single parameter can lose its stability either at a limit point or at a point of bifurcation. Both critical points are associated with divergence instability [1]; flutter instability is ruled out except when gyroscopic forces are present [1,2]. Divergence occurs when the Hessian of the potential function vanishes. Bifurcation and limit points played a central role in the development of the general theory of elastic stability. Even the behavior of imperfect structural systems, which involve an additional control parameter (an imperfection parameter) was referred to these points [34, 31].

As emphasized earlier, systems are often under the influence of several parameters, and it has been pointed out [35] that bifurcation and limit points are not quite adequate to fully describe the behavior of such systems. Thus, a reclassification of critical conditions based on the concept of an equilibrium surface was introduced. In this classification, proper surfaces are distinguished from improper (degenerate) surfaces and two types of critical points, namely general and special points, are used to describe proper and improper surfaces, respectively.

A general nonlinear multiple-parameter theory of stability was developed on the basis of these concepts [32]. The catastrophe theory [33], which essentially parallels this approach, provides a qualitative description of phenomena that might arise under certain circumstances. These so-called elementary catastrophes are constructed via the concept of universal unfoldings in a structurally stable way and can be linked to general points. In fact, it has been demonstrated [6, 36-38] that the ***simple general*** point and the ***singular general*** point correspond to fold catastrophe and Riemann-Hugoniot catastrophe respectively.

An analytical pattern has been established [36] to obtain the swallowtail, butterfly, and other higher order surfaces using the multiple-parameter perturbation technique [32]. This technique provides a systematic tool for quantitative analyses and also yields the umbilics associated with two-fold critical points. The technique can in fact be used to analyze the behavior of a system in the vicinity of n-fold (compound) critical states [6, 37-39].

The effect of symmetry on the imperfection sensitivity of coincident critical points has been explored in great detail [40]. It has been observed [38] that the equilibrium equations describing the equilibrium surface in the vicinity of a symmetric point of bifurcation can be associated with the organizing center of the double-cusp catastrophe. This point and the circumstances under which imperfection sensitivities are related to a particular umbilic have been discussed [41].

Nongradient systems do not have a potential, however, so that basing the formulation and conclusions on a well-behaved function (the potential) might have to be abandoned. In addition, nongradient systems can exhibit oscillatory instabilities (flutter) as well as divergence. It is thus possible that a dynamic formulation will be essential to any study of such general response characteristics.

A dynamic system can be described by either Lagrangian equations or a set of first order differential equations (state-space formulation). Linear studies concerning dynamical system in mechanics are usually carried out on the basis of the former formulation, the latter is widely used in such disciplines as electrical networks and control theory. Because the second order Lagrangian equations can readily be transformed into the state-space equations with an appropriate transformation of variables, the state-space formulation seems a suitable and unifying approach for nonlinear analysis of all autonomous systems, nongradient and gradient.

Consider the first order equation

$$\dot{x} = X(x, \eta) \tag{1}$$

where x is a vector of n components in an euclidean space E_n, η is a scalar parameter, and dot denotes differentiation with respect to time t. The salient features of this system are described by equilibrium states and limit cycles (periodic motions). The equilibrium states of the system are characterized by the vanishing vector field $X(x, \eta) = 0$ defined over an euclidean manifold E_{n+1} of dimension (n+1). These equations define certain equilibrium paths in E_{n+1}.

Consider an initial path in a region of interest assumed to be stable for sufficiently small values of η. Attention is focused on stability properties, the critical value of η, the nature of instability, and post-critical behavior. The eigenvalues of the Jacobian evaluated on the initial path generally have negative real parts in the stable region; complex eigenvalues appear in conjugate pairs. Stability can be lost at a critical value of η at which point either the real part of at least a pair vanishes (flutter) or the Jacobian becomes singular (divergence). In the case of flutter the vanishing real parts become positive for higher values of η, and the flutter instability leads to limit cycles. In the case of divergence, the Jacobian can become singular at a simple (r-fold compound) critical point if one (r) pair(s) of complex conjugate eigenvalues or one (r) real eigenvalue(s) vanishes at the critical point. At a simple divergence point the nullity of the Jacobian is one.

It has been demonstrated analytically [42] that a divergence point on an equilibrium path (particularly on the initial path) can generally be identified as either a point of bifurcation or a limit point, in complete analogy with gradient systems. The conditions giving rise to these phenomena and their interrelationship are explored, and it is shown that the limit points are associated with fold catastrophes [42]. The asymptotic equations of the bifurcating post-critical paths have been obtained in general terms [43, 44].

The well-known asymmetric and symmetric points of bifurcations can also arise in nongradient systems. Compound critical points, on the other hand, are associated with multi-furcations, in which several post-critical paths branch off from the initial path with significant imperfection sensitivities [43]. The stability of equilibrium states can be determined on the basis of the eigenvalues of the Jacobian evaluated at given points on the equilibrium paths. This method has been used [45] to examine the stability distribution in the vicinity of a branching point. Explicit conditions of stability and instability for the initial and post-critical paths were obtained through a perturbation procedure. At an asymmetric point of bifurcation an exchange of stabilities between paths occurred, in complete analogy with gradient systems. Similarly, a symmetric point of bifurcation involves a post-critical path that is totally stable (unstable) if the initial path is unstable (stable).

When a system is under the influence of several independent parameters, the parameter η in Equation (1) becomes a vector parameter of m components where m is the number of independent parameters. The concepts of ***general*** and ***special*** critical points used to describe the instability behavior of gradient systems have been extended to autonomous systems [46]. This classification helps identify and characterize critical divergence conditions associated with all autonomous systems, gradient and nongradient. Thus, a divergence point is said to be ***general (special)*** if the rank of a certain parameter matrix is equal to (less than) the nullity of the Jacobian matrix.

Analogous to the gradient systems is the fact that equilibrium surface in the vicinity of a general point is smooth and has well-defined normals. Depending on the properties of the system, this surface assumes distinct forms that can be associated with catastrophes [47]. Explicit equations of these distinct forms of surfaces are constructed through the multiple-parameter perturbation technique asymptotically. This development represents the first direct generalization of elementary catastrophes to nongradient systems [68].

Another approach [48, 49] has been used to investigate one-parameter divergence instability of discrete nongradient systems: the frequency in the Lagrangian equations is set equal to zero, and the system is assumed to exhibit a trivial initial path. The equilibrium paths in the vicinity of a critical point can be explored with this method but the formulation does not allow for a stability analysis of the paths.

If the critical point on the initial path is a flutter point at which the real part of a pair of complex conjugate eigenvalues associated with equation (1) vanishes, a bifurcation occurs known as a Hopf bifurcation. Hopf's Theorem asserts that, if the function X (x, η) in equation (1) is analytic in the region of interest and the derivative of the real part of the pair with respect to η at the critical point does not vanish, then, in addition to the initial path (which without loss of generality can be defined by $x \equiv 0$ for all η), equation (1) has a family of periodic solutions for $\eta > \eta_{cr}$ or $\eta < \eta_{cr}$. Hopf presented his theory in 1942, renewed interest is attributable to a desire to solve practical problems. A book [50, 51] devoted to various aspects of Hopf bifurcation deals with both discrete and continuous systems.

The Hopf bifurcation is similar to the bifurcation of equilibrium paths generated at a divergence critical point. If the amplitude (or a measure of it) of the periodic solutions is treated as a behavior variable, then, in the amplitude-parameter subspace, a branching off from the flutter point on the initial path is observed. This post-critical curve, the associated limit cycles, their stability, and the transients leading to these periodic solutions can be determined by different methods.

The methods involving singular perturbations, for example, are often used and have been described [52]. In nonlinear systems the amplitude-frequency relationship must be accounted for; ordinary expansions can lead to terms that cannot be present in a periodic motion. Singular perturbation methods are designed to overcome these difficulties. Multiple time scaling is one such method that has been used [53] to explore the limit cycles, their stability, and other characteristics in the vicinity of a flutter point. There always exists a limit cycle either for $\eta < \eta_{cr}$ (unstable limit cycle) or for $\eta > \eta_{cr}$ (stable limit cycle). The solution is obtained in the form of an asymptotic expansion in the neighborhood of $\eta = \eta_{cr}$. The transient response and the analytical expression for the limit cycle amplitude are also given.

The method of multiple scales, though more involved, has advantages over the Lindstedt-Poincaré method, for example, it can treat damped systems conveniently [52]. Methods based on averaging have also been described [52]. A method of averaging and integral manifolds [54] has been used to study transient motions and the method of Hopf for obtaining the amplitude and period of motions associated with an autonomous system having gyroscopic and circulatory forces. The second order ordinary differential equations are first transformed into first order equations similar to equation (1); analyses are based on these equations [54].

The Lagrange equations of an undamped imperfect structural system have been considered and the method of harmonic balancing applied to obtain periodic solutions [55]; it is assumed that the perfect system has no pre-critical deformations and that the equations of motion are linear in η. The method of harmonic balancing expresses the periodic solution as a sum of harmonics and equates the coefficients of each of the lowest harmonics to zero after the assumed solution is substituted into the governing equations. The resulting set of algebraic equations relates frequency and amplitude. Nonlinear oscillations have also been described elsewhere [56].

The Hopf bifurcation and related topics have attracted the attention of both mathematicians and engineers. Recent publications include a comprehensive article [57] on factorization theorems and repeated branching of solutions at a simple eigenvalue; global Hopf bifurcation from a multiple eigenvalue [58], attractivity and Hopf bifurcation [59]; Hopf-Frederichs bifurcation theory [60]; and a study of periodic and steady-state mode interactions [61]. Holmes [62] has presented a finite-dimensional analysis concerning bifurcations to divergence and flutter in flow-induced oscillations. Huilgol [63] applied Hopf-Frederichs bifurcation theory to determine when a periodic orbit will bifurcate from the equilibrium position of a railway axle. The application of the Hopf bifurcation theorem to nonlinear oscillations in circuits and systems has been presented [64]. Other work has also been reported [65, 66]. Work on the Hopf bifurcation under the influence of several parameters is still in a developmental stage [67, 69].

REFERENCES

1. Huseyin, K., "Vibrations and Stability of Mechanical Systems," Shock Vib. Dig., 8 (4), pp 56-66 (1976).

2. Huseyin, K., Vibrations and Stability of Multiple-Parameter Systems, Sijthoff & Noordhoff Intl. Publ. (1978).

3. Huseyin, K., "Standard Forms of the Eigenvalue Problems Associated with Gyroscopic Systems," J. Sound Vib., 45, pp 29-37 (1976).

4. Huseyin, K., "The Effect of Damping on the Flutter Boundary of Rotating Systems," Intl. Conf. Vibrations of Rotating Machinery, Cambridge, 1976, Proc. Instn. Mech. Engr., England, pp 133-137 (1976).

5. Müller, P.C., Stabilität und Matrizen, Springer (1977).

6. Huseyin, K., Part II of "Stability of Elastic Structures," Ed. by H.H.E. Leipholz, Springer-Verlag Wien, pp 100-180 (1978).

7. Bahar, L.Y., Kwatny, H.G., and Massimo, F.M., "Direct and Inverse Variational Characterization of Linear Nonconservative Systems," Hadronic J., 1, pp 976-1011 (1978).

8. Bahar, L.Y. and Kwatney, H.G., "Exact Lagrangians for Linear Nonconservative Systems," Hadronic J., 2, pp 238-260 (1979).

9. Yan, C.C., "Construction of Lagrangians and Hamiltonians from the Equations of Motion," Amer. J. Physics, 46, pp 671-675 (1978).

10. Santilli, R.M., Foundations of Theoretical Mechanics, Part I, The Inverse Problem in Newtonian Mechanics, Springer-Verlag (1978).

11. Santilli, R.M., Foundations of Theoretical Mechanics, Part II, Generalization of the Inverse Problem in Newtonian Mechanics, Springer-Verlag (in press).

12. Kwatny, H.G., Massimo, F.M., and Spare, J.H., "Canonical Representations and Averaging in the Construction of Reduced Order Models with Physical Structure," Proc. Joint Aut Cont. Conf., IEEE, 2, pp 534-544 (1977).

13. Kwatny, H.G., Bahar, L.Y., Space, J.H., and Massimo, F.M., "Hamiltonian Representations and Averaging for Reduced Order Models," Proc. Engr. Fndn. Conf., Pacific Grove, CA (Apr 23-28, 1978)

14. Athel, S. and El Naschie, M.S., "A Variational Approach to the Stability Analysis of Nongradient Discrete Systems," Proc. IUTAM Symp., Evanston, IL, Ed. Nemat Nasser, Pergamon Press (1979)

15. Nicholson, D.W., "A Note on Vibrations of Damped Linear Systems," Mech Res. Comm., 5, pp 79-83 (1978)

16. Müller, P.C., Remarks on "Vibrations of Damped Linear Systems," Mech. Res Comm., 6, pp 7-15 (1979)

17 Nicholson, D.W., "On the Forced Vibrations of a Damped Linear System," Mech. Res. Comm., 5, pp 73-77 (1978).

18. Nicholson, D.W., " Eigenvalue Bounds for Damped Linear Systems," Mech. Res. Comm., 5, pp 147-152 (1978)

19. Müller, P.C., "Oscillatory Damped Linear Systems," Mech. Res. Comm., 6, pp 81-85 (1979).

20 Beskos, D.E., "The Effect of Damping on the Vibration-Stability Relation of Linear Systems," Mech Res Comm., 3, pp 373-377 (1976).

21 Baruch, M., "On the Shape Modes of Damped Systems," J. Appl. Mech., Trans. ASME, 45, pp 951-952 (1978).

22. Fawzy, I., "A Theorem on the Free Vibrations of Damped Systems," J Appl. Mech., Trans. ASME, 44, pp 132-134 (1977)

23. Fawzy, I and Bishop, R.E.D., "On the Dynamics of Linear Nonconservative Systems," Proc. Royal Soc. (London), Series A, Math Phys. Sci., 352, pp 25-40 (1976).

24. Wahed, I.F.A. and Bishop, R.E.D.,"On the Equations Governing the Free and Forced Vibrations of a General Nonconservative System," J. Mech. Engr. Sci., 18, pp 6-10 (1976).

25. Walter, W.W and Anderson, G.L., "Stability of a System of Three Degrees of Freedom Subjected to a Circulatory Force," J. Sound Vib., 45, pp 105-114 (1976).

26. Hauger, W., "On the Dynamic Behaviour of Dissipative Circulatory Structural Systems," J. Sound Vib., 56, pp 575-581 (1977).

27. Beskos, D.E., "Critical Damping Surfaces of Linear Dynamic Systems," 3rd Engr. Mech. Specialty Conf., Austin, TX, Proc. by ASCE, pp 722-725 (1979).

28. Huseyin, K. and Hagedorn, P., "The Effect of Damping on the Stability of Pseudo-Conservative Systems," Z. Angew. Math. Mech., 58, T147-T148 (1978).

29. Teschner, W., "Zur Instabilität Konservativer Systeme mit Gyroskopischen Kräften," Z angew Math. Mech., 57, pp T92-T94 (1977).

30 Magnus, K., "Zur Theorie von Mehrkorpersystemen mit drehzahlgeregelten Rotoren," Ing. Arch., 45, pp 209-216 (1976).

31. Thompson, J.M.T. and Hunt, G.W., A General Theory of Elastic Stability, John Wiley & Sons (1973)

32 Huseyin K "Nonlinear Theory of Elastic Stability," Noordhoff Intl. Publ. (1975).

33. Thom, R., Structural Stability and Morphogenesis, trans by D.H. Fowler, Benjamin Inc. (1975).

34. Koiter, W.J., "On the Stability of Elastic Equilibrium," Dissertation, Holland (1945).

35. Huseyin, K., "Elastic Stability of Structures under Combined Loading," Ph.D Thesis, Univ London (1967)

36. Huseyin, K., "The Multiple-Parameter Stability Theory and its Relation to Catastrophe Theory," Problem Analysis in Science and Engineering, ed. by F. Branin and K. Huseyin, Academic Press (1977).

37. Huseyin, K. and Mandadi, V., "Classification of Critical Conditions in the General Theory of Stability," Mech. Res. Comm., 4, pp 11-15 (1977).

38. Huseyin, K., Discussion Related to the Paper "On the Imperfection Sensitivity of Compound Branching," Ing. Arch., 47, pp 315-318 (1978).

39. Huseyin, K. and Mandadi, V., "On the Imperfection Sensitivity of Compound Branching," Ing. Arch., 46, pp 213-222 (1977).

40. Mandadi, V. and Huseyin, K., "The Effect of Symmetry on the Imperfection Sensitivity of Coincident Critical Points," Ing. Arch., 47, pp 35-45 (1978).

41. Huseyin, K., "Catastrophe Theory and Problems in Elastic Stability," Symp. arranged by Soc. Natural Philosophy, Virginia (Apr 1978).

42. Mandadi, V. and Huseyin, K., "Nonlinear Instability Behaviour of Nongradient Systems," Hadronic J., 2, pp 657-681 (1979).

43. Mandadi, V. and Huseyin, K., "Nonlinear Bifurcation Analysis of Nongradient Systems," Intl. J. Nonlinear Mech., 15, pp 159-172 (1980).

44. Huseyin, K. and Mandadi, V., The Post-Critical Behaviour of Nongradient Systems, Proc. 7th CANCAM, pp 247-248 (1979).

45. Huseyin, K., "On the Stability of Equilibrium," J. Appl. Mech., Trans. ASME (to be published).

46. Mandadi, V. and Huseyin, K., "A Classification of Critical Conditions in the Stability Theory of Nongradient Systems," Mech. Res. Comm., 4, pp 179-183 (1977).

47. Huseyin, K., "General Critical Points Associated with Autonomous Systems," Proc. 3rd ASCE/EMD Specialty Conf., Austin, Tx, pp 232-235 (1979).

48. Plaut, R.H., "Post-buckling Analysis of Nonconservative Elastic Systems," J. Struct. Mech., 4, pp 395-416 (1976).

49. Plaut, R.H., "Branching Analysis at Coincident Buckling Loads of Nonconservative Elastic Systems," J. Appl. Mech., Trans. ASME, 44, pp 317-321 (1977).

50. Marsden, J.E. and McCracken, M., "The Hopf Bifurcation and Its Applications, Springer-Verlag (1976).

51. Sethna, P.R. and Sell, G.R., Review of The Hopf Bifurcation and Its Applications, J. Appl. Mech., Trans. ASME, 45, pp 234-235 (1978).

52. Nayfeh, A.H. and Mook, D.T., Nonlinear Oscillations, John Wiley & Sons (1979).

53. Smith, L.S. and Morino, L., "Stability Analysis of Nonlinear Differential Autonomous Systems with Applications to Flutter," AIAA J., 14, pp 333-341 (1976).

54. Sethna, P.R. and Schapiro, S.M., "Nonlinear Behaviour of Flutter Unstable Dynamical Systems with Gyroscopic and Circulatory Forces," J. Appl. Mech., Trans. ASME, 44, pp 755-762 (1977).

55. Burgess, I., "Flutter Instability in Imperfect Structural Systems," Intl. J. Nonlinear Mech., 11, pp 157-168 (1976).

56. Hagedorn, P., "Nichtlineare Schwingungen," Akademische Verlagsgesellschaft, Wiesbaden (1978).

57. Joseph, D.D., "Factorization Theorems and Repeated Branching of Solutions at a Simple Eigenvalue," Ann. N.Y. Acad. Sci., 316, pp 150-167 (1978).

58. Chow, Shui-Nee and Yorke, J.A., "Global Hopf Bifurcation from a Multiple Eigenvalue; Nonlinear Analysis, Theory, Methods & Applications," 2, pp 753-763 (1978).

59. Negrini, P. and Salvadori, L., "Attractivity and Hopf Bifurcation Nonlinear Analysis," Theory, Methods & Applications, 3, pp 87-99 (1979).

60. Poore, A.B., "On the Theory and Application of the Hopf-Friederichs Bifurcation Theory," Arch. Rat. Mech. Anal., 60, pp 371-393 (1976).

61. Langford, W.F., "Periodic and Steady-State Mode Interactions Lead to Tori," SIAM J. Appl. Math., 37, pp 22-48 (1979).

62. Holmes, P.J., "Bifurcations to Divergence and Flutter in Flow Induced Oscillations: A Finite Dimensional Analysis," J. Sound Vib., 53, pp 471-503 (1977).

63. Huilgal, R.R., "Hopf-Friederichs Bifurcation and Hunting of a Railway Axle," Quart. Appl. Math., 36, pp 85-94 (1978).

64. Mees, A.I. and Chua, L.O., "The Hopf Bifurcation Theorem and Its Applications to Nonlinear Oscillations in Circuits and Systems," IEEE Trans. Circuits Systems, Cas-26, pp 235-254 (1979).

65. Gurel, O. and Rossler, D.E. (Eds.), "Bifurcation Theory and Applications in Scientific Disciplines," Ann. N.Y. Acad. Sci., 316, (1979).

66. Schmidt, G. (Ed.), VII. Internationale Konferenz uber Nichtlineare Schwingungen, Academie-Verlag (1977).

67. Takens, F., "Unfoldings of Certain Singularities of Vector Fields: Generalized Hopf Bifurcations," J. Diff. Eqtn., 14, pp 476-493 (1973).

68. Huseyin, K. and Mandadi, V., "On the Instability of Multiple-Parameter Systems," Proc. of 15th IUTAM Congress, Toronto, 1980, North Holland Publ.

69. Huseyin, K., Atadam, S., "On the Hopf Bifurcation," to be published.

BOOK REVIEWS

FAILURE PREVENTION AND RELIABILITY

S.E. Bennett, A.L. Ross, and P.Z. Zemanick, Eds.
ASME Des. Engrg. Tech. Conf., Chicago, IL
Sept 26-28, 1977, ASME: 1977, NY, 309 pp, $30

A new discipline is emerging, as shown by the 20 papers contained in this publication. If the stress numbers calculated by design engineers were less than the limits, the design was considered to be good. This is changing. Failure prevention and reliability have emerged as factors that the responsible mechanical designer must consider to assure a good design. And the advent of sophisticated equipment has made failure prevention and reliability prime design targets.

I. Reliability Assurance in Practice.

Four papers discuss various topics: safety and reliability design objectives of the Clinch River Breeder Reactor plant, reliability of a nuclear power plant steam turbine overspeed control system, means for lowering the failure pressure of a safety rupture diaphragm, and proper evaluations of turbomachinery shaft-nut connections. The last paper describes the establishment of a modified Goodman diagram and evaluation of stress results.

II. Failure Analysis Studies

The first paper discusses the analyses required to assure the safe design of a solvent recovery system. Included is an analysis of core buckling (inner screen) and proper protection from stress corrosion cracking of the outer screen. Major problems in a corrosive environment were solved by a judicious combination of mechanical testing and analysis. Other papers discuss failure analysis of a pump impeller and proper utilization of vibration testing and fracture mechanics to improve design. Four papers consider the following topics: failure analysis, testing, and product improvement of a BWR control drive component; a self-destructing diesel engine, failure analysis of a 20 mm gun component using finite elements; and failure of an experimental turbine rotor.

III. Techniques for Failure Prevention Assessment

Subjects include: experimental determination of stress concentration factors in torsion for stepped hollow shafts; a rational theory of failure for combined high-cycle fatigue; a monte carlo approach to stress-strength interference; and failure prevention by experimental stress analysis. The last paper contains a concise explanation of good and bad aspects of photoelastic techniques, electrical resistance strain gages, and brittle coatings. The techniques are applied to a gate valve, a shut-off valve, and stresses during the assembly of large nuclear reactor pressure vessels. This informative paper lists considerations involved in selecting the proper measuring technique.

IV. Equipment Reliability

This section considers failure experience feedback in design improvement, computer methods for qualitative fault tree analysis, establishment of equipment for failure rate data bases, risk management, and probabilistic design methods for reliability. The last topic contains information about prediction of the reliability of mechanical components and structural members. Lower one-sided confidence levels in reliability occur at 90% and 95% regions. It is worth the reader's time to study this paper.

This symposium is timely as to contents. The energy crisis and more efficient mechanical systems require the engineer to be more precise in his design analysis. Reliability will become more and more importnat in assuring that products meet all safety requirements in preventing mechanical failures. Proper utilization of the latest methods of failure analysis will have to be used. This book is recommended to mechanical designers interested in failure prevention and reliability.

H. Saunders
General Electric Company
Schenectady, New York 12345

LAGRANGIAN MECHANICS OF NONCONSERVATIVE NONHOLONOMIC SYSTEMS

D.G.B. Edelen
Noordhoff International Publishing, Leyden, The Netherlands, 1977

In attempting to judge the value of a treatise on any subject of the physical sciences, one is compelled to ask several questions: how well is the subject presented, how useful will the book be to the prospective buyer of the volume, how accessible is the material to the reader, how valuable will the text become in the future when readers become more familiar with the style and the approach chosen by the author, and does it contain anything fundamentally new that might be used to extract solutions to an intractable problem?

Let it be stated from the beginning that this reviewer considers himself an engineer with a keen interest in analytical mechanics, to the extent of applying algorithms to the solution of engineering type problems, in particular those problems that allude to nonconservative and nonholonomic systems, as, for example, surface vehicle systems.

It is unfortunate that the author fails to present examples, not even simple ones, in the field of particle mechanics, to illustrate his point. However, this omission alone should not suggest that the method of Cartan's calculus of exterior forms, which the author brings to bear in reformulating some classical dynamics problems, does not offer a more elegant and possibly even simpler means for solving such problems. Even if it does, the reader had be better prepared to learn a new algebra based primarily on the geometric notion of tangent vector fields. The author expects some familiarity by the reader with the calculus of exterior forms. Even without providing specific examples it is presumed that, for the purpose of computer calculations, certain simplifications can be realized by means of Cartan's calculus of exterior forms. In an attempt to make the treatise more readable, the author has given in the Appendix a step by step review of the theorems and lemmas of Cartan's calculus, the notation is explained when necessary.

This reviewer believes that the book is slightly ahead of its time; that is, engineering scientists are simply not yet endowed with the mathematical prerequisites required for complete understanding of the treatise. I did not find either new solutions to old familiar problems or solutions to higherto unsolved problems. The greatest value of the volume lies the fact that it exposes the reader to a new formulation of classical mechanics.

H.K. Sachs
Department of Mechanical Engineering
Wayne State University
Detroit, Michigan 48202

VIBRATION MEASUREMENT

G. Buzdugan, E. Mihailescu, and M. Rades
Rumanian Socialist Republic Academic Press, 1979
(In Rumanian)

As indicated by the authors, who are members of the Strength of Material Laboratories at the Polytechnic Institute of Bucharest, this book summarizes what has to be measured and by what means with regard to vibration; less information is given on how and with what specific instrument. Indeed, the authors have had good access to the more technical and general western literature on vibration measurement but limited access to more specific product literature. They give little mention to such advanced technology devices as minicomputers and portable spectrum analyzers. This text contains good brief reviews of instrumentation basics and excellent philosophical passages on the practice of vibration measurements and testing.

Chapter 1 discusses the nature of mechanical vibration (harmonic, transient, random, and resonance) and the concept of measuring to find response, to find forcing, or to find estimates of the dynamic parameters of the system tested. The relationship of displacement, velocity, and acceleration is discussed, as is the general nature of transducers, recorders, calculators, integrators, multipliers, and filters.

Chapter 2 is a good, brief review of the elements of the mathematical theory of vibration – linear and nonlinear models, single and multiple degrees of freedom, free and forced vibration, damping, Fourier series and transforms, transfer functions, correlation, power spectral density, probability distribution, and the vibration of plates and beams. Chapter 3 briefly reviews the effects of vibration on man and machines. Levels of perception, nuisance, and damage are noted.

Chapters 4 and 5 discuss transducer and instrument theory and provide limited product information. Included are servo, piezoelectric, piezoresistive, capacitive, inductive and electrodynamic transducers, and some simple circuity for their readout. Extensive data on the East German METRA line and some data on B & K and French accelerometers are given. Proper accelerometer mounting techniques are presented. Similarly little hard information, but much general theory, is presented for instruments and their operating specification. Little mention is made of minicomputers or similar processors, the use of the FFT, or extensive use of solid state or digital hardware.

Mechanical, electromagnetic, electrodynamic, and hydraulic vibrators are discussed at length in Chapter 6. Theory, typical designs, and typical limits are reviewed. Chapter 7 reviews instrumentation setups and techniques for vibration measurement. These include choice of transducers and typical setups for measuring amplitude, phase, random series properties, spectra, and transfer functions. Sinusoidal impulses and random and pulse train excitations are discussed.

Chapter 8 briefly reviews transducer calibration procedures and Chapter 9 gives some examples of vibration measurement projects, including milling machines and overhead cranes (prototypes); turbine blades (location of source vibration); machine tools, hydraulic lines, electric motors, and rail vehicles (product acceptance testing); and blasting vibrations and tests to determine material properties.

The text contains many interesting and useful practical descriptions and philosophical passages; it also contains an insight into vibration testing methods in the eastern countries. It falls short in descriptions of specific products available and of advanced technology devices; more detailed examples in use, especially for large and aerospace structures should be given. I feel that, should an English version become available, the book is worth reviewing; but hard specifications, designs, product information, and examples have been better documented in existing English language publications.

P. Ibanez
ANCO Engineers
Santa Monica, California 90404

SHORT COURSES

JANUARY

PROBABILISTIC AND STATISTICAL METHODS IN MECHANICAL AND STRUCTURAL DESIGN

Dates: January 5-9, 1981
Place: Tucson, Arizona
Objective: The objective of this short course and workshop is to provide practical information on engineering applications of probabilistic and statistical methods and design under random vibration environments. Modern methods of structural and mechanical reliability analysis will be presented. Special emphasis will be given to fatigue and fracture reliability.

Contact: Dr. Paul H. Wirsching, Associate Professor of Aerospace and Mechanical Engineering, The University of Arizona, College of Engineering, Tucson, AZ 85721 - (602) 626-3159/626-3054.

DYNAMIC ANALYSIS IN TURBOMACHINERY DESIGN

Dates: January 12-16, 1981
Place: Madison, Wisconsin
Objective: The short course will be of interest and value to engineers and scientists in industry, government and education. Topics include dynamics of rotating shafts, dynamic response of turbomachinery blading and bladed disk systems and of stationary vanes. Aspects discussed for blades and vanes will include linear modal analysis and lumped mass analysis, effects of damping treatments and frictional damping, measurements of modal functions by laser holographic interferometry. Aspects discussed for rotor dynamics will include flexible and rigid bearings, damping, and coupled transverse and angular motion. Practical problems and case histories will be reviewed to illustrate methods of solution and to illustrate analytical results.

Contact: Dr. Donald E. Baxa, Program Director, University of Wisconsin-Extension, Department of Engineering and Applied Science, 432 North Lake Street, Madison, WI 53706 - (608) 262-2061.

FEBRUARY

MACHINERY DATA ACQUISITION

Dates: February 2-6, 1981
June 1-5, 1981
August 3-7, 1981
September 28 - October 2, 1981
December 7-11, 1981
Place: Carson City, Nevada
Objective: This seminar is designed for people whose function is to acquire machinery data for dynamic analysis, using specialized instrumentation, and/or that person responsible for interpreting and analyzing the data for the purpose of corrective action on machines. Topics include measurement and analysis parameters, basic instrumentation review, data collection and reduction techniques, fundamental rotor behavior, explanation and symptoms of common machinery malfunctions, including demonstrations and case histories. The week also includes a lab workshop day with hands-on operation of the instrumentation and demonstration units by the participants.

Contact: Marketing Training Department, Bently-Nevada Corporation, P.O. Box 157, Minden, Nevada 89423 - (702) 782-3611, Extension 224.

INTRODUCTION TO GIFTS 5 - USER WORKSHOP

Dates: February 9-13, 1981
Place: Tucson, Arizona
Objective: It is expected that the user is familiar with the fundamentals of the finite element method and intends to use the GIFTS program as a pre- and post-processor or as an analysis package. Apart from lectures dealing with the theoretical and numerical aspects, ample time will be devoted to gaining experience with GIFTS by solving a number of selected examples and user projects.

Contact: Dr. Hussein A. Kamel, Professor of Aerospace and Mechanical Engineering, The University of Arizona, College of Engineering, Tucson, AZ 85721 - (602) 626-1650/626-3054.

ROTOR DYNAMICS ENGINEERING

Dates: February 16-18, 1981
Place: Daytona Beach, Florida
Objective: This intensive course has been especially designed for specialists, engineers, and scientists working in industrial and governmental facilities involved with rotor dynamics. This course provides participants with an understanding of the principles of rotor dynamics and the application of these principles to practical problems in rotor dynamics engineering.

Contact: Union College, Office of Graduate Studies, 1 Union Avenue, Schenectady, NY 12308 - (518) 370-6288.

APPLIED VIBRATION ENGINEERING

Dates: February 16-18, 1981
Place: Daytona Beach, Florida
Objective: This intensive course is designed for specialists, engineers and scientists working in industrial, governmental and educational institutions involved with design against vibration or solving of existing vibration problems. This course provides participants with an understanding of the principles of vibration and the application of these principles to practical problems of vibration reduction.

Contact: Union College, Office of Graduate Studies, 1 Union Avenue, Schenectady, NY 12308 - (518) 370-6288.

MARCH

FIXTURE DESIGN FOR VIBRATION AND SHOCK TESTING

Dates: March 2-6, 1981
Place: St. Petersburg, Florida
Objective: The seminar is designed mainly for dynamics test personnel desiring an understanding of practical approaches to the design and fabrication of text fixtures used in vibration and shock testing. Most of the potential students are employed by test activities of Government and military facilities, as well as major defense contractors.

Contact: Wayne Tustin, 22 East Los Olivos St., Santa Barbara, CA 93105 - (815) 682-7171.

MACHINE PROTECTION

Dates: March 3-4, 1981
Place: Houston, Texas
Dates: April 22-23, 1981
Place: Chicago, Illinois
Dates: April 28-29, 1981
Place: Buffalo, New York
Dates: May 6-7, 1981
Place: Edmonton, Alberta, Canada
Dates: September 16-17, 1981
Place: New Orleans, Louisiana
Dates: October 20-21, 1980
Place: Houston, Texas
Dates: October 27-28, 1981
Place: Pittsburgh, Pennsylvania
Objective: This is our most basic seminar. It provides an in-depth examination of proximity measurement, probe installation techniques, and monitoring systems including types, functions, and calibration procedures. In addition, Bently-Nevada provides an overview of some of the instrumentation used for vibration analysis including oscilloscopes, scope cameras, and specialized filter instruments. The seminar is designed for those individuals responsible for installation and proper operation of in-place monitoring systems - maintenance technicians, instrument engineers, and operators.

Contact: Marketing Training Department, Bently-Nevada Corporation, P.O. Box 157, Minden, NV 89423 - (702) 782-3611, Extension 224.

ADVANCED GIFTS 5 USER WORKSHOP AND GIFTS 5 SYSTEMS WORKSHOP

Dates: March 9-13, 1981
Place: Tucson, Arizona
Objective: Two parallel sessions are planned, an advanced user workshop (AW), intended for users already familiar with GIFTS, and a systems workshop (SW), aimed at the programmer who intends to modify, implement or add to the system. The last dav of the week will be devoted to a GIFTS Users Group meeting, in which GUG members may present papers and interact on various issues.

Contact: Dr. Hussein A. Kamel, Professor in Aerospace and Mechanical Engineering, College of Engineering, University of Arizona, Tucson, AZ 85721 - (602) 626-1650/626-3054.

MEASUREMENT SYSTEMS ENGINEERING

Dates: March 9-13, 1981

Place: Phoenix, Arizona

MEASUREMENT SYSTEMS DYNAMICS

Dates: March 16-20, 1981

Place: Phoenix, Arizona

Objective: Program emphasis is on how to increase productivity, cost-effectiveness and data-validity of data acquisition groups in the field and in the laboratory. Emphasis is also on electrical measurements of mechanical and thermal quantities.

Contact: Peter K. Stein, 5602 East Monte Rosa, Phoenix, AZ 85018 - (602) 945-4603/946-7333.

MECHANICAL ENGINEERING

Dates: March 30 - April 3, 1981
August 31 - September 4, 1981

Place: Carson City, Nevada

Objective: This is our most comprehensive presentation cf rotor dynamics theory, and machinery malfunction descriptions and demonstrations. A guest speaker in the field of rotor dynamics is invited to present the theoretical portion of the seminar. A full day will be spent in a rotor lab workshop allowing individual instruction and operation of the demonstration units. This session is designed for the mechanical engineer who has responsibility for the proper operation of major rotating machinery.

Contact: Marketing Training Department, Bently-Nevada Corporation, P.O. Box 157, Minden, NV 89423 - (702) 782-3611, Extension 224.

NEWS BRIEFS: news on current and Future Shock and Vibration activities and events

NOISEXPO '81 FEATURES UNIQUE MINI-COURSE PROGRAM

NOISEXPO '81, the National Noise and Vibration Control Conference and Exhibition, will be presented April 6-9, 1981 at the Hyatt Regency O'Hare, near Chicago's O'Hare Airport.

The conference program features a unique series of mini-courses on noise and vibration control, noise and vibration measurements, modal analysis, environmental noise regulation, and related topics. Presented by highly-skilled professionals, the mini-course sessions cover basic and advanced material. NOISEXPO registrants may select from one to eight course units specifically tailored to their own information needs.

The conference program also includes a series of technical sessions featuring papers and workshop discussions on selected problem areas within the general topics of industrial noise control, instrumentation and measurements, product design and testing, environmental noise, and hearing conservation.

NOISEXPO '81 serves individuals who are concerned with noise and vibration control and related topics. Engineers, technicians and managers from industry; personnel from governmental agencies; educators; and researchers will benefit from the program.

The NOISEXPO '81 exhibition features instrumentation for noise and vibration measurement, products for noise and vibration control, and equipment for hearing conservation programs.

For further information, contact: NOISEXPO, 27101 East Oviatt Road, Bay Village, OH 44140 - (216) 835-0101.

IES 2nd NATIONAL CONFERENCE & WORKSHOP
Announcement and Call for Papers

The Institute of Environmental Sciences will hold its 2nd National Conference and Workshop on Environmental Stress Screening of Electronic Hardware on September 21-25, 1981 at the San Jose Hyatt House, San Jose, California.

Since the first ESSEH Conference and Workshop in early 1979, government and industry has focused considerable attention on the utility of environmental stress screening as a cost-effective technique for precipitating latent part and manufacturing defects prior to delivery of electronic hardware. Thermal cycling and random vibration and the synergistic relationship between these screens has been of particular interest.

Accordingly, the Institute of Environmental Sciences has sponsored a project to develop screening guidelines based on the collection and analysis of industry screening program data. A second National Conference and Workshop will be conducted to present these guidelines and to provide a forum for the presentation of papers representing the state-of-the-art on the subject. Typical of topics considered appropriate for the paper sessions are:

- Environmental Stress Screening Theory
- Screening Program Development/Implementation
- Screening Case Histories
- Contract Language for Screening
- Costs vs Benefits of Screening
- New Screening Methods
- Screening Facilities and Test Equipment Considerations

The papers can cover any or all levels of assembly from parts to complete systems. Deadline for submission of papers is February 1, 1981.

For further information, contact: August L. Lena, ESSEH Technical Program Co-Chairman, Hughes Aircraft Company, Bldg. 21, Mail Station M116, Centinela and Teale Streets, Culver City, CA 90230 - (213) 391-0711, Ext. 4944.

52nd SHOCK AND VIBRATION SYMPOSIUM
Meeting Announcement

The 52nd Shock and Vibration Symposium will be held on October 27, 28, and 29, 1981 at the Monteleone Hotel, New Orleans, Louisiana. The Defense Nuclear Agency will be the host. The initial "Call for Papers" is expected to be issued by early March 1981.

For further information, contact: Henry C. Pusey, Director, The Shock and Vibration Information Center, Code 5804, Naval Research Laboratory, Washington, D.C. 20375 - (202) 767-2220.

11th Transducer Workshop
June 9-11, 1981
Seattle, Washington

The 11th Transducer Workshop will be held in Seattle, Washington on June 9-11, 1981. The Workshop is a gathering of people interested in measuring physical parameters with transducer technology. Applications are in flight, field, and laboratory testing.

The objectives of this workshop are:

- Provide a common forum for people whose principal interests are identified with transducers.
- Give participants the opportunity to learn what state-of-the-art work is being done by colleagues.
- Provide for discussion of real problems in measurement and solutions using hardware, technique, and know-how.
- Identification and discussion of what's new in techniques, transducers, and applications.
- Promote improvement of communications between transducer users and manufacturers, to further mutual assistance in problem solving and to improve capabilities.

The Workshop is sponsored by a Transducer Committee of the Telemetry Group, which reports to the Range Commanders Council of the national test ranges.

Workshops are just what the name says; everyone is expected to contribute something from his knowledge and experience. The ratio of paper presentations to open discussions is about 1:4. As a knowledge-sharing work session, the participants are the program in a very real sense. The extent and enthusiasm of everyone's knowledge-sharing determines the success of the Workshop. These elements have been a tradition since the first workshop.

For further information, contact: Charles E. Thomas, AFWAL/FIBG, WPAFB, OH 45433 - (513) 255-4127, Autovon: 785-4127.

REVIEWS OF MEETINGS

SECOND INTERNATIONAL CONFERENCE ON VIBRATIONS IN ROTATING MACHINERY

Churchill College, Cambridge
September 1-4, 1980

Reviewed by Ronald L. Eshleman, Ph.D.
Director, The Vibration Institute
Clarendon Hills, IL 60514

The demands of the societies of the world for goods produced with ever increasing efficiency and less energy have motivated the design of high-speed, lightweight machinery. One unavoidable by-product of such machinery, mechanical vibration, must be faced by the designer, developer, and user.

Churchill College, Cambridge was the venue for the Second International Conference on Vibrations in Rotating Machinery held on 1 to 4 September, 1980. This successful conference was sponsored by the Applied Mechanics Group of the Institution of Mechanical Engineers. Cosponsors included the American Society of Mechanical Engineers, The Japan Society of Mechanical Engineers, Verein Deutscher Ingenieure, and the International Federation for the Theory of Machines and Mechanisms. The planning panel and its chairman, Paul G. Morton of GEC Power Engineering Ltd., Stafford, are to be congratulated for organizing an informative meeting that stimulated discussions of various new technology. Sixty-eight papers, to be published as a bound proceedings by the Institution, were presented and discussed by more than 280 delegates from 23 countries.

The Conference was the first international meeting at which engineers interested in mechanical signature analysis were able to exchange information on assessing machine faults from vibration signals. The conference also provided a forum for discussion of the latest research results on rotor-bearing-foundation dynamics and balancing.

The formal opening lecture by Professor K. Federn of the Technische Universitaet, Berlin had to do with the development by mechanical engineers of "technical slaves" to do work. Professor Federn traced the early history of modern machine development beginning with the invention of the steam engine by James Watt (see separate article in this issue). He illustrated his concept of the "technical slave" by relating the energy utilized by enslaved individuals to that used by such equipment as airplanes. The opening session also featured a lecture by Dr. D.M. Smith titled "Recognition of Causes of Rotor Vibration in Turbomachinery". Dr. Smith spoke about his many experiences in the machine vibration field.

Mr. Morton directed the activities of the Conference Dinner and proposed toasts to the Queen, heads of state of countries represented, and the sponsoring institutions. Mr. Bryan Hildrew, President of the Institution of Mechanical Engineers, responded to a toast to guests and authors by the reviewer. Professor Stephen Crandall of Massachusetts Institute of Technology responded to the toast to the sponsoring institutions. He mentioned the fact that the Institution has held the Royal Charter for fifty years and that 1980 is the centennial anniversary of the American Society of Mechanical Engineers.

The papers presented at the conference were oriented toward research, development, and practical application of vibration technology in mechanical equipment including turbines, motors, engines, pumps, compressors, generators, gearboxes, printing machines, rolling mills, and gyroscopes. Vibrations associated with such components of mechanical systems as shafts, rotors, bladed disks, impellers, bearings, seals, casings, and foundations were also addressed. Characterizations of stiffness and damping properties were reported for bearings, squeeze film dampers, and seals. Among the techniques described for determination, assessment, and control of vibration were computational methods, monitoring, diagnosis, and balancing.

Several sessions were devoted to papers on specific topics. Instabilities in rotor-bearing systems were the focus of a session; the papers in the first half of the session contained descriptions of parametric rotor support systems and asymmetrical rotors supported by asymmetrical foundations and a physical explanation of parametric instabilities in unsymmetric rotors. The second half of the session on instabilities contained papers on the effects of unbalance on the stability threshold of rotor-bearing systems.

A session was held on bearings and dampers. The first half of the session focused on the experimental identification of bearing stiffness and damping parameters. The papers had to do with estimating seal-bearing stiffness and damping and identifying stiffness and damping coefficients of journal bearings using the impact method. The second half of the session was devoted to characterization of various forms of the squeeze-film damper. That gear drives continue to stimulate industrial interest was evident during a strong session in which such aspects of gear drives as modeling, application, monitoring, and defect identification were discussed. Standards and specifications for monitoring gearboxes were given in conjunction with the use of vibration spectra for the diagnosis of faults.

Control of vibration through balancing – particularly for flexible rotors – continues to draw attention. A session on balancing contained descriptions of such techniques as the use of mathematical programming, the polar plotting method during machine startup, processing surplus information in computer-aided balancing, and double overhung compressors with skewed wheels and bowed shafts. One paper described a unified approach to flexible rotor balancing that integrates the influence coefficient method and the modal methods.

Double frequency (two times rotational frequency) excitation in turbogenerators was the topic of papers on calculation of the vibration behavior of coupled rotating shafts containing a transverse crack, anisotropy of bearings, and weight effects. Three papers on vibrations in gyroscopes dealt with bearings, bearing suspensions, and dynamic tuning of supports.

Long unrecognized in rotor system modeling, seals were the subject of a strong session on load-dependent low-frequency vibrations of high-pressure rotors on large turbogenerators. The topics included analysis of high pressure oil seals for optimum turbocompressor dynamic performance, effect of labyrinth seals on rotor whirl instability, and spring and damping coefficients of labyrinth seals.

The role of foundations in the modeling of rotor-bearing systems for calculation of critical speeds and rotor response was discussed during a session on casings and foundations. Papers were presented on the influence of casing stiffness, techniques for computation of coupled machine/foundation vibrations, and techniques for reduction of problem size prior to computation.

The closing session contained papers on practical vibration analysis of a high pressure steam turbine in a large ammonia plant, coupling selection in engine test beds, and coupling effects on the vibration in steel rolling mill drives.

Prior to his closing remarks Mr. Morton accepted comments and criticisms on the conference and solicited ideas for future meetings. He thanked the authors and delegates for their contributions and summarized the meeting. He noted that many of the papers had to do with rotor dynamics and balancing – as was the case in 1976 at the First International Conference -- and that seals received increasing attention. He expressed surprise at the lack of papers on turbomachinery blading and noted that more papers on quantitative data are needed – an opinion enthusiastically seconded by this reviewer.

Although the results of the Second International Conference on Vibrations in Rotating Machinery have yet to be digested and applied, the information presented will be cited for its contributions to vibration technology. This Conference is the continuation of a successful dialogue among engineers – designers, developers, and users – concerned with vibrations in rotating machinery.

51ST SHOCK AND VIBRATION SYMPOSIUM

21-23 October 1980
Holiday Inn at the Embarcadero
San Diego, California

The 51st Shock and Vibration Symposium, sponsored by the Shock and Vibration Information Center

(SVIC), was held in San Diego, California in October. It was hosted by the Naval Ocean Systems Center of the United Sates Navy. The formal technical program consisted of more than 75 papers (see Vol. 12, No. 9 of the **DIGEST** for the complete program; paper summaries are available from SVIC; papers will be published in the **SHOCK AND VIBRATION BULLETIN**). A series of technical plenary sessions were conducted during the symposium. Mr. Edward F. Noonan delivered the second Elias Klein Memorial Lecture – "An Approach to the Limitation and Control of Shipboard Vibration". Henry Pusey, Director of the SVIC, the members of the SVIC staff, and the Program Committee are to be congratulated for assembling an interesting program. Among the 350 participants were representatives of the federal government, industry, and academic institutions. The combination of formal and informal technical programs effected a meaningful transfer of shock and vibration technology.

The Opening Plenary Session

The opening plenary session was chaired by Dr. Richard Swim, Superintendent, Marine Technology Division, Naval Research Laboratory. The keynote address was given by Mr. James E. Colvard, Deputy Chief of Naval Material, Naval Material Command. He noted that the design of weapon systems is the bottom line of this activity and that in the material acquisition process sharing of common information gathered is critical - rather than replicating past bad experiences. Mr. Colvard stressed the need for technical excellence. He noted that in running programs standards of excellence must be maintained; and, an age mix of technical people is necessary to obtain continuity.

Mr. Colvard predicted that in the wars of the future we will not have the option of substituting the manufacture of autos for tanks. We will not have time to convert from peace to war activities. It is important that governmental management keep this fact in mind. He noted that while SVIC operates in a narrow field it is a critical one. There is no greater obligation to be right than when nobody can judge whether you are right or wrong. You can expect criticism in a field that can be judged. He commended the SVIC for its work in the technical information area.

Mr. Edward F. Noonan of NKF Engineering Associates, Inc. gave the second Elias Klein Memorial Lecture on "An Approach to the Limitation and Control of Shipboard Vibration". Mr. Pusey introduced the speaker and noted that he was one of the persons who attended the first Shock and Vibration Symposium in 1947. Mr. Noonan stressed the importance of shipboard vibration including structural integrity, mechanical suitability, and human inhabitability to ship operation and performance. He reviewed some history of early work and organization at the Bureau of Ships and its predecessors the Bureaus of Steam Engineering and Construction and Repair starting in 1939 when he came to Washington. The older ships had reciprocating steam engines and some like the Midway and Coral Sea had serious screw vibration problems. He noted that Professor Den Hartog came to the Bureau of Ships during this time.

Mr. Noonan emphasized the need for specifications. He insisted that we still do not have satisfactory design methods to build ships free of excessive vibration. Tradition has it that hydrodynamicists and/or naval architects design the ships and the vibration engineer is left to patch up any vibration problems. While there is much theoretical research on wake forces it does not mean that the ship is designed free of vibration. The shock effects look dramatic; however, the vibration effects cause noise, fatigue, and failures. Corrosion fatigue has become a problem.

Mr. Noonan, who had an influence on the development of the MIL-STD-167 on shipboard mechanical vibration, discussed its development and application. He discussed the fact that the Navy paid in excess for equipment due to tight standards. He intimated that today the Navy is paying more for equipment which is below the normal commercial quality. He discussed the Nautilus, Polarius, and Spruance ship classes with respect to the details of shock and vibration including design, development, and testing.

Mr. Noonan proposed that studies be conducted to see why we have good and bad ships. Ships of all sizes provide a good field laboratory - but they are not used. Not enough investigations of why problems occur are made. He also stressed the need for unified standards. He discussed his activities within the International Standards Organization from 1975 to 1980.

Mr. Noonan concluded that all shock and vibration aspects must be related to specifications and that these aspects must be a line item in the procurement and development processes. Otherwise they will not be heeded.

Dr. David J. Ewins of Imperial College of Science and Technology, London, gave an invited presentation on "State-of-the-Art Assessment of Mobility Measurements: A Summary of European Results". Dr. Ewins discussed mobility measurement techniques developed thirty years ago on shipboard machinery vibrations. The state-of-the-art assessment of mobility measurements in Europe was made by issuing standard models to participating laboratories. These model tests had a 2-2000 Hz dynamic range. The object of the exercise was to find out how repeatable the tests were. Three types of data were requested: 1) mobility curves, 2) modal analyses and modal properties of structures, and 3) dynamic properties of substructures. The dynamic properties of substructures were used to obtain the properties of structures. Dr. Ewins showed the measurement results from several structures tested by different laboratories. He compared the results obtained from different excitation tests – sinusoidal, random, and transient. In conclusion, results of these tests were mixed – he noted that more cross checks including reciprocity measurements are needed. (A similar test program for mobility measurements on specified models is now being organized in the United States by the SVIC.)

Plenary Lectures

Colonel Ben H. Swett, Office of the Undersecretary of Defense for Research and Engineering, delivered a plenary lecture on the "Department of Defense Policy on Reliability and Maintainability". Colonel Swett noted with an example how the Department of Defense often inadvertantly rewards those who produce goods of poor quality. He noted how Directive 5000.40 provides a sharp distinction between reliability engineering and accounting – it does require both and a balanced program for a good return on investment.

Colonel Swett described the two types of testing required – developmental and proof testing. In the developmental tests, components and systems are tested, analyzed and fixed – failures are not bad. In the proof testing, qualification is sought – failures are bad. DOD has always emphasized proof tests. Directive 5000.40 has redefined reliability in terms of mission and maintenance aspects. He noted that MIL-STD-810 snould be identified with the test-fix-test developmental tests.

In conclusion, Colonel Swett defined the new reliability and maintainability policies in DOD, stressed the prerequisites to R&M by design, terminology, growth, cost effectiveness, and acquisition program phases. He noted that the test-fix-test procedure will get problems out early and eliminate failures in proof tests.

The second plenary lecture was given by Mr. Robert Dyrdahl, Chief of Structural Dynamics, Boeing Company, on "Necessary and Sufficient Qualifications on Shock". Mr. Dyrdahl noted that we need better design techniques and shock qualifications. In addition, efficient technology transfer is required because we don't have time to reinvent the wheel. He discussed typical equipment and the complex design process. Rules of thumb and minor calculations are used for concept development and preliminary design. Final design calculations are made with component mode synthesis and finite element calculations. He discussed shock test facilities and factors of safety noting that conservatism generally adds reliability.

Mr. Dyrdahl discussed the U.S. balance of trade deficits and how they could be improved by better technology, more research, and technology transfer. In this light he issued a challenge to the SVIC: to accomplish major improvement in defining the detailed unified methods and guidelines to ensure necessary and sufficient qualifications for shock and vibration. Mr. Dyrdahl elaborated on the analytical methods including concept design, preliminary design, final design, and test support. Test methods and specifications for concept development, preliminary design and final design were discussed. The procedures should be related to the product and include both analysis and test methods Some of the specific items discussed were definition of design loads, test data extrapolation, and combination of methods.

In conclusion, he noted that the SVIC document would not only assist in the U.S. balance of trade but also give assurance to U.S. users of equipment.

Technical Program

The formal technical program consisted of nine sessions containing full length papers and one session on short discussion topics. Sessions oriented to specific hardware including submarine shock and ship dynamics. The papers on specific ship hardware were mainly analytical in nature – descriptions of phenomena and techniques to solve practical problems.

Sessions on environmental testing and shock testing were of interest for their general testing techniques like the improved recursive formula for calculating shock response spectra by D.O. Smallwood. Most papers were applied to specific hardware on aircraft, missiles, and ships. An associated session on specifications and reliability featured an interesting opening lecture on myths and sacred cows in shock and vibration by Henry Caruso. An interesting paper involving the assessment and comparison of vibration specifications was given by J.H. Schmidt. In general, his was a good overall session on criteria and testing requirements.

An active session on damping and isolation contained several papers on the application of the finite element method to the prediction of the vibration response of damped and isolated structures. Papers on the properties of viscoelastic materials and their application to structures were of interest.

Mathematical analysis applied to the modeling and calculation of the vibration response of structures was the subject of sessions - Dynamic Analysis, Shock Analysis, and Analysis. These sessions featured papers on offshore platforms, blading, beams with moving loads, media structure interaction, rotating machinery, and liquids. Among the interesting papers in the session on shock analysis was buckling in cylindrical shells due to whipping excitations and a shock response spectrum method of solution for displacement forcing by F.C. Nelson. The Analysis session contained much new material on parameter identification, modal analysis, and structural synthesis. These techniques were applied to aircraft flutter, ground transport suspensions, shipping containers, and aircraft.

The Fifty First Shock and Vibration Symposium was both technically informative and interesting. Again like the Fiftieth, the plenary sessions added an interesting dimension to the meeting. The plenary speakers added the overviews and interesting philosophical insights needed in a meeting of this scope. The plenary talks helped unify the technical material presented in the meeting. Papers presented at the symposium will be reviewed for quality of technical content and published in the 51st **SHOCK AND VIBRATION BULLETIN** available from the SVIC.

R.L.E.

ABSTRACT CATEGORIES

MECHANICAL SYSTEMS

- Rotating Machines
- Reciprocating Machines
- Power Transmission Systems
- Metal Working and Forming
- Isolation and Absorption
- Electromechanical Systems
- Optical Systems
- Materials Handling Equipment

STRUCTURAL SYSTEMS

- Bridges
- Buildings
- Towers
- Foundations
- Underground Structures
- Harbors and Dams
- Roads and Tracks
- Construction Equipment
- Pressure Vessels
- Power Plants
- Off-shore Structures

VEHICLE SYSTEMS

- Ground Vehicles
- Ships
- Aircraft
- Missiles and Spacecraft

BIOLOGICAL SYSTEMS

- Human
- Animal

MECHANICAL COMPONENTS

- Absorbers and Isolators
- Springs
- Tires and Wheels
- Blades
- Bearings
- Belts
- Gears
- Clutches
- Couplings
- Fasteners
- Linkages
- Valves
- Seals
- Cams

STRUCTURAL COMPONENTS

- Strings and Ropes
- Cables
- Bars and Rods
- Beams
- Cylinders
- Columns
- Frames and Arches
- Membranes, Films, and Webs
- Panels
- Plates
- Shells
- Rings
- Pipes and Tubes
- Ducts
- Building Components

ELECTRIC COMPONENTS

- Controls (Switches, Circuit Breakers)
- Motors
- Generators
- Transformers
- Relays
- Electronic Components

DYNAMIC ENVIRONMENT

- Acoustic Excitation
- Shock Excitation
- Vibration Excitation
- Thermal Excitation

MECHANICAL PROPERTIES

- Damping
- Fatigue
- Elasticity and Plasticity

EXPERIMENTATION

- Measurement and Analysis
- Dynamic Tests
- Scaling and Modeling
- Diagnostics
- Balancing
- Monitoring

ANALYSIS AND DESIGN

- Analogs and Analog Computation
- Analytical Methods
- Modeling Techniques
- Nonlinear Analysis
- Numerical Methods
- Statistical Methods
- Parameter Identification
- Mobility/Impedance Methods
- Optimization Techniques
- Design Techniques
- Computer Programs

GENERAL TOPICS

- Conference Proceedings
- Tutorials and Reviews
- Criteria, Standards, and Specifications
- Bibliographies
- Useful Applications

ABSTRACTS FROM THE CURRENT LITERATURE

Copies of articles abstracted in the DIGEST are not available from the SVIC or the Vibration Institute (except those generated by either organization). Inquiries should be directed to library resources. Government reports can be obtained from the National Technical Information Service, Springfield, VA 22151, by citing the AD-, PB-, or N- number. Doctoral dissertations are available from University Microfilms (UM), 313 N. Fir St., Ann Arbor, MI; U.S. Patents from the Commissioner of Patents, Washington, D.C. 20231. Addresses following the authors' names in the citation refer only to the first author. The list of periodicals scanned by this journal is printed in issues 1, 6, and 12.

ABSTRACTS CONTENTS

MECHANICAL SYSTEMS

ROTATING MACHINES

(Also see Nos. 69, 76, 94, 174, 186, 190, 191, 212)

81-1

Finite Element Analysis of Turboexpander Vane Vibrations

R.J. Schaller and R.B. Currie

Air Products and Chemicals, Inc., Allentown, PA, Reliability, Stress Analysis and Failure Prevention Methods in Mechanical Design, Intl. Conf., Aug 18-21, 1980, San Francisco, CA, W.D. Milestone, ed.; ASME: 1980, pp 181-184, 5 figs, 1 table, 8 refs

Key Words: Impellers, Fatigue life, Vanes, Finite element technique

The finite-element analysis of a radial-inflow turboexpander impeller is described with regard to fatigue damage to the vanes. Selection of a suitable finite-element code is discussed, along with suggestions on developing the model.

81-2

Numerical Treatment of Helicopter Rotor Stability Problems

R. Vepa and T.S. Balasubramanian

National Aeronautical Lab., Bangalore, India, Emerging Technologies in Aerospace Structures, Design, Structural Dynamics and Materials, Aerospace Conf., Aug 13-15, 1980, San Francisco, CA, J.R. Vinson, ed.; ASME: 1980, pp 307-319, 6 figs, 14 refs

Key Words: Helicopter rotors, Stability, Numerical analysis

The problem of calculating the Floquet transition matrix for parametric stability problems is considered. A new method of calculating the transition matrix with a minimum number of time steps is described. The method is shown to be extremely efficient for a wide class of helicopter stability problems.

81-3

Development of Advanced Rotor/Bearing Systems for Feed Water Pumps. Final Report

M.L. Adams, Jr. and E. Makay

Akron Univ., OH, 45 pp (Nov 1979)

EPRI-FP-1274

Microfiche copies only

Key Words: Rotor-bearing systems, Pumps, Design techniques, Vibration reduction

Many common feed pump failures are associated with or directly caused by excessive pump vibration. A four-phase project has been undertaken to develop pump design improvements and new configurations whch potentially reduce pump vibration and related failures. Phase 1 of this project has been completed and is summarized.

81-4

Non-Linear Dynamic Analysis of Rotors by Finite Element Method

A.V.K. Murty and A. Raman

Dept. of Aeronautical Engrg., Indian Inst. of Science, Bangalore 560012, India, J. Sound Vib., 69 (4), pp 559-568 (Apr 22, 1980) 3 figs, 6 tables, 8 refs

Key Words: Rotors (machine elements), Nonlinear theories, Finite element technique, Natural frequencies

Non-linear natural vibration characteristics and the dynamic response of hingeless and fully articulated rotors of rectangular cross-section are studied using the finite element method. In the formulation of response problems, the global variables are augmented with appropriate additional variables, facilitating direct determination of sub-harmonic response. Numerical results are given showing the effect of the geometric non-linearity on the first three natural frequencies.

81-5

Aspects of Shaft Dynamics for Industrial Turbines

L. Busse, D. Heiberger, and J. Wey

Brown Boveri Rev., 67, pp 292-299 (May 1980) 14 figs

Key Words: Shafts (machine elements), Unbalanced mass response, Lateral vibration, Computer programs

To provide precise information on the vibration behavior of industrial turbines, a computer program was developed to determine natural lateral frequencies and vibrations caused by unbalance. This technique has proved to be very reliable, as verified by experience with countless turbosets.

81-6

Crankshaft Design and Evaluation - Part 2 - A Modern Design Method: Modal Analysis

E. Bargis, A. Garro, and V. Vullo

Progettazione e Sperimentazione, Torino, Italy, Reliability, Stress Analysis and Failure Prevention Methods in Mechanical Design, Intl. Conf., Aug 18-21, 1980, San Francisco, CA, W.D. Milestone, ed., ASME: 1980, pp 203-211, 11 figs, 2 tables, 8 refs

Key Words: Crankshafts, Shafts (machine elements), Modal analysis, Design techniques

A modern crankshaft design method, having a broad validity range and free from most limitations, is presented. The dynamic analysis of crankshafts is carried out using the modal analysis method and the results are experimentally verified.

81-7

Crankshaft Design and Evaluation - Part 3 - Modern Design Method: Direct Integration

E. Bargis, A. Garro, and V. Vullo

Fiat Auto S.p.A. Progettazione e Sperimentazione, Torino, Italy, Reliability, Stress Analysis and Failure Prevention Methods in Mechanical Design, Intl. Conf., Aug 18-21, 1980, San Francisco, CA, W.D. Milestone, ed., ASME: 1980, pp 213-218, 6 figs, 1 table, 4 refs

Key Words: Crankshafts, Shafts (machine elements), Nonlinear theories, Computer programs, Design techniques

Results of a crankshaft dynamic analysis obtained by a general computer program developed for this purpose, are reported. Theoretical stress values on fillets are checked.

81-8

On the Development of Traveling Load Finite Elements

J. Padovan and I. Zeid

The Univ. of Akron, Akron, OH 44325, Computers Struc., 12 (1), pp 77-83 (July 1980) 13 figs, 19 refs

Key Words: Rotating structures, Moving loads, Finite element technique

Specialized finite elements are devised to handle traveling load problems in stationary and moving/rotating semi-infinite and body of revolution structures. The generality of the elements is such that the full range of rectilinear/rotary loading and structural velocities can be handled. Such phenomena as resonances and standing as well as traveling sub/supersonic waves can be simulated. The accuracy and capabilities of the elements are demonstrated by several numerical examples.

RECIPROCATING MACHINES

81-9

The Use of Slide Valve Pumps - The Means for an Active Noise Insulation of Machine Tool Hydraulic Drives (Einsatz von Sperrschieberpumpen - ein Mittel zur aktiven Geräuschminderung hydraulischer Antribe für Werkzeugmaschinen)

St. Sommerschuh and G. Schmeisser

Forschungszentrum des Werkzeugmaschinenbaues im VEB Werkzeugmaschinenkombinat, 'Fritz Heckert' Karl-Marx-Stadt, Maschinenbautechnik, 29 (1), pp 15-16 (1980) 4 figs, 2 refs

Key Words: Pumps, Hydraulic equipment, Machine tools, Noise reduction

Use of a sliding valve pump in a hydraulic cabinet instead of a gear pump is described. The soundless pump gives a uniform oil flow and results in a slight pressure change in the hydraulic cabinet.

POWER TRANSMISSION SYSTEMS

81-10

Dynamic Model of a Hydraulic Motor with Cycloidal Toothing and with a Planetary Motion of the Rotor (Dynamisches Modell eines Hydromotors mit zykloidaler Verzahnung und mit einer Planetenbewegung des Rotors)

P.D. Nhuan and A. Oledzki

Tech. University of Warsaw, Poland, Maschinenbautechnik, 29 (1), pp 34-37 (1980) 10 figs, 6 refs

Key Words: Hydraulic equipment, Fluid drives, Gear drives, Pumps, Mathematical models

A dynamic model of a hydraulic motor with cycloidal toothing and a planetary motion of the rotor is described. Modifications of the mathematical description and change of the direction of energy flow result in a model of a hydraulic pump with the same design as the motor.

STRUCTURAL SYSTEMS

BRIDGES

81-11

Vertical Vibration Analysis of Suspension Bridges

A.M. Abdel-Ghaffar

Dept. of Civil Engrg., Princeton Univ., Princeton, NJ, ASCE J. Struc. Div., 106 (ST 10), pp 2053-2075 (Oct 1980) 7 figs, 11 refs

Key Words: Bridges, Suspension bridges, Natural frequencies, Mode shapes

A method of analysis is outlined for free vertical vibrations of suspension bridges. The method employs a digital computer and a finite element approach, and uses a linearized theory which restricts the amplitudes of vibrations to be small. The analysis is designed to determine the natural frequencies, modes of vibration, and energy storage capacities of the different members of the bridge. Both symmetric and anti-symmetric modes of vibrations are considered.

81-12

Estimation of Fatigue Life of Railway Bridges under Traffic Loads

L. Fryba

Railway Res. Inst., Prague, Czechoslovakia, J. Sound Vib., 70 (4), pp 527-541 (June 22, 1980) 17 figs, 2 tables, 16 refs

Key Words: Bridges, Fatigue life, Traffic-induced vibration, Moving loads

Random modeling of railway bridge loading enables fatigue damage to be calculated on the basis of the cumulative damage theory of Palmgren-Miner and the classification of the stress-time history by means of the "rain-flow" counting method. A detailed study of the effects on the bridge life of different parameters is presented.

BUILDINGS

81-13

A Technique for Predicting the Performance of Self-Protecting Buildings with Respect to Traffic Noise

D.J. Oldham and E.A. Mohsen

Dept. of Bldg. Science, Univ. of Sheffield, Sheffield S10 2TN, UK, Noise Control Engr., 15 (1), pp 11-19 (July/Aug 1980) 8 figs, 19 refs

Key Words: Buildings, Traffic noise, Noise reduction

The results of computer simulation and scale model experiments on typical self-protecting building forms are analyzed. A design chart suitable for predicting the performance of a given self-protecting building, is shown.

81-14

Insertion Loss Measurements of Small Rectangular Enclosures

E.J. O'Keefe and D.R. Stewart

Construction Machinery Div., Clark Equipment Co., P.O. Box 547, Pipestone Rd., Benton Harbor, MI 49022, Noise Control Engr., 15 (1), pp 20-27 (July/Aug 1980) 14 figs, 16 refs

Key Words: Noise reduction, Enclosures, Buildings

Insertion loss measurements for two rectangular enclosures were made in a reverberant room. The data were then compared with the one-dimensional models of Jackson and Junger, the diffuse model of Ver, and a normal mode model. The results indicate a leveling of insertion loss without using absorptive material at high frequencies, and near random incidence insertion loss behavior with absorptive material.

81-15

Seismic Stability of Block Structures

R.L. Fulgerson

Ph.D. Thesis, Univ. of California, San Diego, 120 pp (1980)

UM 8018779

Key Words: Buildings, Concrete, Seismic response

For the purpose of analysis, earthquake damaged reinforced concrete or concrete masonry structures with degraded connections are modeled as assemblages of rigid substructures with only friction acting between them. A statistical analysis of data from experiments on concrete masonry members gives an asymptotic Coulomb law describing this friction which is included in the model equations of motion. The equations of motion for a simple shear-wall-floor slab assemblage subjected to simulated earthquake loading are solved numerically.

81-16

Seismic Response of Light Attachments to Buildings

R. Villaverde and N.M. Newmark

Dept. of Civil Engrg., Illinois Univ. at Urbana-Champaign, IL, STRUCTURAL RESEARCH SER-469, 442 pp (Feb 1980)

PB80-185028

Key Words: Buildings, Seismic design

An approximate simple method for predicting the response of secondary systems attached to buildings subjected to earthquakes is presented. The method is based on the premise that interaction between a primary and secondary system can be accounted for by analyzing the interconnected system constructed by such primary and secondary systems. The response spectrum method is used to determine the maximum response of the assembled system, and analytical expressions are derived for each step.

81-17

Aseismic Reinforcement of Existing Buildings

N.F. Forell and G.J.P. Nordenson

Forell/Elsesser Engrs., Inc., San Francisco, CA, ASCE J. Struc. Div., 106 (ST9), pp 1907-1919 (Sept 1980) 10 figs

Key Words: Buildings, Seismic design, Standards and codes

The differences between possible methods of reinforcement of buildings against seismic forces and the variations in the desired results are presented. Examples cited use criteria ranging from reasonable protection of life through total code compliance to optimum protection of life and property.

81-18

Dynamic Analysis Methods for Nuclear Facilities

B.K. Horsager

Hanford Engrg. Development Lab., Richland, WA, Rept. No. CONF-790804-2, 12 pp (Apr 20, 1979) HEDL-SA-1738-FP

Key Words: Buildings, Nuclear power plants, Dynamic structural analysis, Computer programs

A comparison is made of three different dynamic analysis methods commonly used in the analysis of nuclear facilities. The methods are applied to a typical non-reactor type nuclear facility. The fuel handled is mixed plutonium and uranium in powder and pellet form which requires design for severe earthquake and tornado conditions. The structure is a two-story reinforced concrete shear wall building with a high bay on one end. The comparison is made for earthquake motion in the lateral horizontal direction only.

TOWERS

81-19

Noise from Natural Draft Cooling Towers

W.L. Reinicke and E.P. Riedel

Muller-BBM GmbH, Robert-Koch-Strasse 11, 8033 Planegg/Munchen, West Germany, Noise Control Engr., 15 (1), pp 28-36 (July/Aug 1980) 15 figs, 1 table, 14 refs

Key Words: Cooling towers, Noise generation, Noise reduction

The sound generation in large natural draft cooling towers are considered on the basis of the pulse excitation mechanism of individual drops. The theoretical and experimental investigations result in some semiempirical formulas which can be used for calculation of the sound power radiated from the air intake and the air exit. The possibilities and limitations of noise reduction efforts can be seen from the presented investigations of individual sources and the sound propagation inside this cooler type.

ROADS AND TRACKS

81-20

A Three-Dimensional Analysis of the Hunting of an Unflanged Railway Wheelpair in its Motion along a Straight Track

C.O. Boyd

Ph.D. Thesis, Univ. of the Witwatersrand, South Africa (1979)

Key Words: Railway vehicles, Interaction: rail-wheel, Hunting motion

The side-to-side oscillatory motion of a railway wheelpair traveling along a straight track is investigated as an exercise in three-dimensional dynamics.

PRESSURE VESSELS

81-21

The Vibration of Core Barrel and Pressure Vessel (Kmitani nosneho valce a tlakove nadoby reaktoru)

K. Větrovec

National Res. Inst. for Machine Design, Prague-Běchovice, Czechoslovakia, Strojnicky Časopis, 31 (3), pp 305-317 (1980) 13 figs, 3 refs
(In Czech)

Key Words: Pressure vessels, Nuclear reactor components, Natural frequencies

In the paper the analysis of a systems: pressure vessel-core barrel is presented. The systems is considered as a double physical pendulum. Natural frequencies are determined either considering coolant influence, either without coolant influence. The dependence of natural frequencies on mutual rigidity and on the type of flow is shown.

POWER PLANTS

(Also see Nos. 18, 21, 120, 180, 187, 208, 217)

81-22

Nonlinear Dynamic Analysis of Prismatic Elements for High-Temperature Gas-Cooled Reactor Cores

H.D. Shatoff, R.W. Thompson, and T.H. Lee

General Atomic Co., P.O. Box 81608, San Diego, CA 92138, Nucl. Engr. Des., 59 (1), pp 185-195 (July 1980) 14 figs, 7 refs

Key Words: Nuclear reactors, Nuclear fuel elements, Computer programs, Nonlinear theories

A discussion of the history and some of the results of a major research and development effort to study the dynamic response of the high-temperature gas-cooled reactor core arrangement to seismic excitation, with respect to advances made in the development of analytical methods, is presented. The computer programs developed to perform the analysis are described, along with certain techniques and the modeling required to utilize them. The purpose is to describe the nonlinear dynamic analysis techniques employed to analyze the HTGR core.

81-23

Flow-Induced Vibration Testing of BWR Feedwater Spargers

M.R. Torres

General Electric Co., San Jose, CA, Flow-Induced Vibration of Power Plant Components, The Pressure Vessels and Piping Conference, PVP No. 41, Aug 12-15, 1980, San Francisco, CA, M.K. Au-Yang, ed., ASME: 1980, pp 159-176, 2 tables

Key Words: Boiling water reactors, Nuclear reactor components, Fluid-induced excitation

To understand the cause of vibration and properly verify improved designs of feedwater spargers, cold flow tests were performed in a full-scale mockup test facility. Flow-induced vibrations similar to those measured and observed in actual plant operation were reproduced at the test facility. Empirical mappings showing regions of high- and low-level vibration as a function of geometry and flow rate are provided. Details of the vibration response and character are also described.

81-24

Seismic Qualification of Equipment - Research Needs

C. Chen and F.L. Moreadith

Gilbert/Commonwealth Engineers and Consultants, Reading, PA 19603, Nucl. Engr. Des., 59 (1), pp 149-153 (July 1980) 2 figs, 8 refs

Key Words: Dynamic tests, Seismic response, Nuclear reactor components, Equipment response, Standards and codes

Research needed to reconcile the differences between the IEEE Standard 344-1975 (Recommended Practices for Seismic Qualifications of Class 1E Equipment for Nuclear Power Stations) and the U.S. Nuclear Regulatory Commission Regulatory Guide 1.100 is described. The effects of shake table mass and stiffness on the dynamic response of equipment tested, and the effect attributable to the difference between methods of attaching to the shake table and the actual in-situ attachment method is also discussed.

81-25

Seismic Qualification Tests of Nuclear Plant Components - Damage Severity Factor Concept

D.D. Kana

Engrg. Sciences Div., Southwest Res. Inst., San Antonio, TX 78284, Nucl. Engr. Des., 59 (1), pp 155-170 (July 1980) 9 figs, 2 tables, 11 refs

Key Words: Dynamic tests, Seismic response, Electric power plants, Nuclear power plants, Nuclear reactor components

A new parameter, defined as a damage severity factor, is developed for comparing severity of seismic qualification tests. It is based on comparative data generated from acceleration and strain responses measured on a typical electrical cabinet subjected to an extensive series of typical qualification test conditions. Additional supporting data is correlated in terms of transfer functions, time histories, response spectra, peak responses, and time-average RMS responses.

81-26

Research Needs for Improved Seismic Safety of Mechanical Equipment in Nuclear Power Plants

J.S. Sethi and B.K. Niyogi

Brown and Root, Inc., P.O. Box 3, Houston, TX 77001, Nucl. Engr. Des., 59 (1), pp 113-115 (July 1980) 3 refs

Key Words: Shock absorption, Electric power plants, Nuclear power plants, Underground structures, Pipelines

Areas of research on shock absorbing multiple supported and buried piping of nuclear power plants are recommended.

81-27

Strength and Stiffness of Reinforced Concrete Containments Subjected to Seismic Loading: Research Results and Needs

R.N. White, P.C. Perdikaris, and P. Gergely

Dept. of Structural Engrg., Cornell Univ., Ithaca, NY 14853, Nucl. Engr. Des., 59 (1), pp 85-98 (July 1980) 14 figs, 1 table, 5 refs

Key Words: Containment structures, Reinforced concrete, Nuclear reactors, Seismic response

Results of an experimental investigation on the strength and stiffness of reinforced concrete subjected to combined biaxial tension and simulated seismic forces are presented. The test specimens represent a section of a wall of a containment structure carrying combined pressurization and seismic loading. Research needs for improved prediction of the response of containment structures to seismic effects are discussed.

81-28

Recommended Research for Improving Seismic Safety of Light-Water Nuclear Power Plants

J.W. Reed, W.A. Von Riesemann, R.P. Kennedy, and C.B. Waugh

Engrg. Decision Analysis Co., Inc., 480 California Ave., Palo Alto, CA 94306, Nucl. Engr. Des., 59 (1), pp 57-66 (July 1980) 1 fig, 3 tables, 2 refs

Key Words: Electric power plants, Nuclear power plants, Seismic response

Recommendations for research to improve the seismic safety of light water reactors are presented based on analysis of the answers to a questionnaire returned by persons or groups working in the area of seismic safety of nuclear power plants.

81-29

Earthquake Response of Nuclear Reactor Buildings Deeply Embedded in Soil

T. Masao, Y. Takasaki, M. Hirasawa, M. Okajima, S. Yamamoto, E. Kawata, Y. Koori, S. Ochiai, and N. Shimizu

Fujita Corp., Nuclear Power Plant Civil and Architecture Dept., 74 Ohdana, Kohoku-ku, Yokohama 223, Japan, Nucl. Engr. Des., 58 (3), pp 393-403 (June 1980) 22 figs, 5 refs

Key Words: Nuclear reactors, Seismic response, Interaction: soil-structure

Experimental and analytical studies are made on the dynamic behavior of deeply embedded structures such as nuclear reactor buildings.

81-30

Critical Seismic Response of Nuclear Reactors

R.F. Drenick, P.C. Wang, C.B. Yun, and A.J. Philippacopoulos

Polytechnic Inst. of New York, Brooklyn, NY 11201, Nucl. Engr. Des., 58 (3), pp 425-435 (June 1980) 9 figs, 5 tables, 13 refs

Key Words: Nuclear reactors, Seismic response

A method for the evaluation of seismic resistance of important structures, particularly nuclear reactor structures, is presented. The method relies on the concept of critical excitation, which is that excitation that will produce the largest response peak for a structural variable of interest.

81-31
Present and Future of Equipment Qualification for Dynamic Loads
G.J. Bohm
Westinghouse Electric Corp., Pittsburgh, PA 15230, Nucl. Engr. Des., 59 (1), pp 143-148 (July 1980) 4 figs, 8 refs

Key Words: Dynamic tests, Shock tests, Nuclear reactor components, Equipment response

Methods being used to justify equipment under transient dynamic loads of extreme magnitudes are reviewed. Future developments needed to obtain a consistent and relible technology are discussed. The potential and direction for future developments combined analysis test to obtain a unified approach are presented.

81-32
Equipment Response Spectra for Nuclear Power Plant Systems
J.L. Sackman and J.M. Kelly
Dept. of Civil Engrg., Univ. of California, Berkeley, CA 94720, Nucl. Engr. Des., 57 (2), pp 277-294 (May 1980) 10 figs, 14 refs

Key Words: Nuclear power plants, Equipment response, Seismic excitation

An analytical method is developed whereby a simple estimate can be obtained of the maximum dynamic response of light equipment attached to a structure subjected to ground motion. The natural frequency of the equipment, modeled as a single-degree-of-freedom system, is considered to be close or equal to one of the natural frequencies of the N-degree-of-freedom structure. This estimate provides a convenient, rational basis for the structural design of the equipment and its installation. The approach is based on the transient analysis of lightly damped tuned or slightly nontuned equipment-structure systems in which the mass of the equipment is much smaller than that of the structure. It is assumed that the information available to the designer is a design spectrum for the ground motion, fixed-base modal properties of the structure, and fixed-base properties of the equipment. The results obtained are simple estimates of the maximum acceleration and displacement of the equipment. The method can also be used to treat closely spaced modes in structural systems, where the square root of the sum of the squares procedure is known to be invalid. This analytical method is also applied to nontuned equipment-structure systems for which the conventional floor spectrum method is mathematically valid. A closed-form solution is obtained which permits an estimate of the maximum response of the equipment to be determined without the necessity to compute time histories as required by the floor spectrum method.

VEHICLE SYSTEMS

GROUND VEHICLES

(Also see Nos. 57, 59, 65, 183, 206, 207)

81-33
Simulation of the Directional Response Characteristics of Tractor-Semitrailer Vehicles
P.S. Fancher, Jr., C. Mallikarjunarao, and R.L. Nisonger
Highway Safety Res. Inst., Michigan Univ., Ann Arbor, MI, Rept. No. UM-HSRI-79-9, 85 pp (Mar 1979)
PB80-189632

Key Words: Articulated vehicles, Steering effects, Digital simulation

The capability of a detailed digital simulation for predicting the response to steering of tractor-semitrailer vehicles in obstacle-avoidance maneuvers, turning near the rollover limit, and steady turning is examined. Measured and simulated results are presented for a three-axle tractor combined with either a van-trailer or a flat-bed trailer.

81-34
Dynamic Hopper Car Test
M. Kenworthy and C.T. Jones
Engrg. Test and Analysis Div., ENSCO, Inc., Alexandria, VA, Rept. No. ENSCO/DOT-FR-77-21, FRA/TTC-80/01, 75 pp (Mar 1980)
PB80-187925

Key Words: Railroad cars, Interaction: rail-wheel

A test designed to establish the relationship between ride performance and track degradation, vehicle component wear, and the combined effect of rail degradation and component wear is described. The test was designed to quantify the dynamic response of freight vehicles to different track structures.

81-35
Theoretical Manual and Users' Guide: Longitudinal-Vertical Train Action Model
S.K. Yin

School of Engrg. and Applied Science, Washington Univ., St. Louis, MO, Rept. No. FRA-ORD-76/278, 69 pp (Apr 1980)
PB80-180557

Key Words: Railroad cars, Impact response (mechanical), Mathematical models

A mathematical model for simulating the longitudinal-vertical motion of railroad cars in impact situations is described. Development and validation of the model was part of a study concerned with the phenomenon of coupler bypass resulting from impact or squeeze.

81-36

Dynamic Response of Finite Length Maglev Vehicles Subjected to Crosswind Gusts

D.P. Garg and T.M. Barrows

Transportation Systems Ctr., Cambridge, MA, Rept. No. DOT-TSC-RSPA-80-5, 63 pp (Mar 1980)
PB80-181373

Key Words: Ground effect machines, Magnetic suspension techniques, Wind-induced excitation

A two-degree-of-freedom model for magnetically levitated finite length vehicles incorporating sway and yaw dynamics is formulated. Aerodynamic lateral forces and yawing moments on the vehicle resulting from constant speed wind gusts are computed using analytical techniques.

SHIPS

(Also see Nos. 70, 116)

81-37

European-Built Sea Barge Carriers; Their Design, Machinery/Hull Interaction; and Investigations into Vibratory Behaviour

G.C. Volcy, M. Baudin, C. Andreau, A. Manner, and S. Seppala

Valmet Oy Shipyard, Helsinki, Finland, Trans. Inst. Mar. Engineers (TM), Vol. 92, Paper 5 (1980) 9 figs, 5 tables, 12 refs

Key Words: Barges, Ships, Ship hulls, Shipboard equipment response, Equipment response, Interaction: ship hull-machinery, Finite element technique

Some considerations connected with the design and building of two 37,850 tdw ships and their machinery are presented. In order to ensure trouble-free operation, extensive studies concerning static and vibratory interaction of machinery and hull were undertaken, involving hydrodynamic excitations as well as treatment from static and dynamic point of view simultaneously, of twin-screw propulsive plant and hull steel-work. Some results of the experimental researches and theoretical calculations are presented as well as their correlation with the measurements obtained on the first ship delivered, which proved vibration-free.

81-38

Interface Nodes Influence on the Natural Frequencies of a Simplified Substructured Ship

F. Pinazzi, L. Ricciardiello, and G. Sani

CE.TE.NA., Italian Ship Res. Assn., Viale IV Novembre, 6-Genova, Italy, Computers Struc., 12 (1), pp 33-47 (July 1980) 17 figs, 19 refs

Key Words: Ships, Natural frequencies

An extensive systematic investigation is made to compare the relative accuracy of different substructuring approaches when a subset of nodes on the interfaces is eliminated. Results obtained on a simplified ship structure are presented.

AIRCRAFT

(Also see Nos. 2, 51, 118, 210)

81-39

Asymmetric Stator Interaction Noise

T.G. Sofrin and D.C. Mathews

Pratt & Whitney Aircraft, East Hartford, CT, J. Aircraft, 17 (8), pp 554-560 (Aug 1980) 10 figs, 4 tables, 2 refs

Key Words: Interaction: rotor-stator, Noise reduction, Turbomachinery

An analysis of the fan noise produced by extraneous propagating modes generated by rotor wake interaction with stator vanes that have random vane angle deviations is given. Comparison of predicted tone levels with model fan data indicates good quantitative agreement.

81-40

Spectral Analysis of Non-Stationary Random Processes. Application to Noise of Flyover Type

M. Ernoult

Office National d'Etudes et de Recherches Aerospatiales, Paris, France, Rept. No. ONERA-NT-1979-4, ESA-TT-639, 180 pp (1979)

Key Words: Spectrum analysis, Random noise, Aircraft noise

Nonstationary noise detected by fixed microphones was studied during the passage of a moving acoustic source with the objectives of measuring the noise radiation pattern and characterizing the spatial distribution of the noise. A time frequency representation of the energy of nonstationary random processes and a series of charts which allows the adaptation of the spectral analysis processes to the treatment of nonstationary signals are presented.

81-41

Response of Nonlinear Aircraft Structural Panels to High Intensity Noise

C. Mei

Dept. of Mech. Engrg. and Mechanics, Old Dominion Univ., Norfolk, VA, Emerging Technologies in Aerospace Structures, Design, Structural Dynamics and Materials. Aerospace Conf., Aug 13-15, 1980, San Francisco. CA, J.R. Vinson, ed.; ASME: 1980, pp 245-272, 13 figs, 3 tables, 17 refs

Key Words: Aircraft, Fatigue life, Acoustic excitation

Lightweight aircraft structures exposed to a high intensity noise environment can fatigue fail prematurely if adequate consideration is not given to the problem. Design methods and design criteria for sonic fatigue prevention have been developed based on analytical and experimental techniques. Most of the analytical work was based upon small deflection or linear structural theory which did not agree with the experimental results.

81-42

Aircraft Longitudinal Force and Energy Equilibrium Presented in the Diagram of Korhammer (Kräftegleichgewicht und Leistungsbilanz der Flugzeuglängsbewegung, grafisch dargestellt im Korhammer-Diagramm)

R. Brockhaus and G. Schänzer

Institut für Flugführung der Technischen Universität, Hans-Sommer-Strasse 66, 3300 Braunschweig, Germany, Z. Flugwiss, 4 (3), pp 128-136 (May/June 1980) 13 figs, 11 refs

Key Words: Aircraft, Graphic methods, Equilibrium methods

A diagram showing the solution of the nonlinear equations of motion of an aircraft is presented, in which the vector polygon of longitudinal forces is linked with the Lilienthal polar. The addition of the triangle of velocity vectors as well as of rectangles representing the balance of power gain and power deficit leads to a very comprehensive representation of the physical relations not only in stationary but also in accelerated flight in the moving atmosphere.

81-43

Experimental and Analytical Transonic Flutter Characteristics of a Geared-Elevator Configuration

C.L. Ruhlin, R.V. Doggett, Jr., and R.A. Gregory

NASA Langley Res. Ctr., Hampton, VA, Rept. No. NASA-TP-1666, L-13544, 30 pp (June 1980)

N80-25321

Key Words: Aircraft, Flutter

Flutter calculations were made for a geared elevator configuration by using two analytical methods based on subsonic lifting surface theory. Both methods analyzed the stabilizer and elevator as a single, deforming surface, but one method also allowed the elevator to be analyzed as hinged from the stabilizer.

81-44

Aircraft Dynamic Response to Damaged Runways

AGARD, Neuilly-sur-Seine, France, Rept. No. AGARD-R-685, 39 pp (Mar 1980)

AD-A085 466/1

Key Words: Aircraft, Interaction: wheel-pavement

A study of the potential problems of aircraft dynamic response to damaged and repaired runways is presented.

81-45

NASA-FAA General Aviation Crash Dynamics Program – A Status Report

R.G. Thomson and R.C. Goetz

NASA Langley Res. Ctr., Hampton, VA, J. Aircraft, 17 (8), pp 584-590 (Aug 1980) 15 figs, 16 refs

Key Words: Crash research (aircraft), Testing techniques, Elastoplastic properties, Energy absorption

The general aviation crash dynamics program involves three basic areas of research: controlled full-scale crash testing, nonlinear structural analyses to predict large deflection elasto-plastic response, and load attenuating concepts for use in improved seat and subfloor structure. Both analytical and experimental methods are used to develop expertise in these areas. Analyses include simplified procedures for estimating energy dissipating capabilities and complex computerized procedures for predicting airframe response.

81-46

Crash Simulation of Composite and Aluminum Helicopter Fuselages Using a Finite Element Program

R. Winter, A.B. Pifko, and J.D. Cronkhite

Grumman Aerospace Corp., Bethpage, NY, J. Aircraft, 17 (8), pp 591-597 (Aug 1980) 12 figs, 2 tables, 5 refs

Key Words: Crash research (aircraft), Helicopters, Computer programs, Finite element technique

A mathematical investigation of the crash impact responses of an all-composite helicopter cockpit section incorporating an energy absorbing concept and one of conventional aluminum construction, using the Grumman DYCAST finite element nonlinear structural dynamics computer program is described.

81-47

Aircraft Crashworthiness Studies: Findings in Accidents Involving an Aerial Application Aircraft

W.R. Kirkham, J.M. Simpson, T.F. Wallace, and P.M. Grape

Office of Aviation Medicine, Federal Aviation Admn., Washington, D.C., Rept. No. FAA-AM-80-3, 44 pp (Apr 1980)

AD-A084 619/6

Key Words: Aircraft, Crashworthiness

Aircraft crashworthiness features are presented in terms of packaging principles. Eighteen accidents involving an aerial application aircraft are presented in regard to crashworthiness findings, crashworthiness being the protection afforded by the aircraft against injury to the pilots from impact forces.

MISSILES AND SPACECRAFT

(Also see No. 210)

81-48

Spacecraft Loads Methodology - Transient vs. Shock Spectra Method

J.C. Chen, J.A. Garba, and M.R. Trubert

Jet Propulsion Lab., California Inst. of Tech., Pasadena, CA, Emerging Technologies in Aerospace Structures, Design, Structural Dynamics and Materials. Aerospace Conf., Aug 13-15, 1980, San Francisco, CA, J.R. Vinson, ed., ASME: 1980, pp 225-243, 5 figs, 7 tables, 15 refs

Key Words: Spacecraft, Launchers, Shock response spectra

The methodology for the establishment of spacecraft loads is strongly influenced by project constraints which include the cost, schedule and allowable weight. The most rigorous approach is the transient loads analysis which requires a composite mathematical model of the spacecraft and launch vehicle. To reduce complexity and cost a shock spectra method has been used to design spacecraft structures. These two methods are evaluated by comparing the loads for several spacecrafts. Flight measured loads are also used in the evaluation.

BIOLOGICAL SYSTEMS

HUMAN

(Also see Nos. 150, 155)

81-49

Aircraft Noise Annoyance Contours: Importance of Overflight Frequency and Noise Level

R. Rylander, M. Bjorkman, U. Ahrlin, S. Sorensen, and K. Berglund

Dept. of Environmental Hygiene, Univ. of Gothenburg, Gothenburg, Sweden, J. Sound Vib., 69 (4), pp 583-595 (Apr 22, 1980) 4 figs, 1 table, 24 refs

Key Words: Human response, Noise tolerance, Aircraft noise

Social survey studies were made to assess the presence of general aircraft noise annoyance and activity disturbances. The noise exposure was expressed as the number of overflights/24 hours and the dB(A) level from the noisiest aircraft type.

81-50
Assessment of Noise Annoyance: The Introduction of a Threshold Level in L_{eq} Calculations
T. Gjestland and G. Oftedal
Acoustics Lab., ELAB The Univ. of Trondheim, Norway, J. Sound Vib., 69 (4), pp 603-610 (Apr 22, 1980) 7 figs, 1 table, 8 refs

Key Words: Noise tolerance, Human response, Equivalent sound levels

A modification of L_{eq} is suggested based on the simple fact that noise below a certain threshold may not be heard, and consequently cannot contribute to the annoyance. Results from laboratory experiments show a reasonably good correlation with subjective evaluation.

81-51
Community Response to Noise from a General Aviation Airport
S.E. Birnie, F.L. Hall, and S.M. Taylor
Dept. of Geography, McMaster Univ., 1280 Main St. West, Hamilton, Ontario L8S 4K1, Canada, Noise Control Engr., 15 (1), pp 37-45 (July/Aug 1980) 6 figs, 10 tables, 6 refs

Key Words: Aircraft noise, Human response

Response to aircraft noise around a small general aviation airport is investigated. The effect of non-noise factors on the response to noise is explored; annoyance, sleep and speech interference, tension, and complaints are also examined to determine how each response is related to noise level.

81-52
Laboratory Annoyance and Different Traffic Noise Sources
E. Ohrstrom, M. Fjorkman, and R. Rylander
Dept. of Environmental Hygiene, Univ. of Gothenburg, Gothenburg, Sweden, J. Sound Vib., 70 (3), pp 333-341 (June 8, 1980) 2 figs, 5 tables, 15 refs

Key Words: Traffic noise, Human response

The acute annoyance reaction to different noise sources – lorries, aircraft, mopeds and trains – was investigated in a laboratory experiment. Students were exposed to different noise climates for 25 minutes, and their reactions were subsequently assessed by using a questionnaire. General sensitivity to noise was also evaluated.

81-53
Predicting the Effects of Vertical Vibration Frequency, Combinations of Frequencies and Viewing Distance on the Reading of Numeric Displays
C.H. Lewis and M.J. Griffin
Inst. of Sound and Vib. Res., Univ. of Southampton, Southampton S09 5NH, UK, J. Sound Vib., 70 (3), pp 355-377 (June 8, 1980) 8 figs, 11 tables, 16 refs

Key Words: Vibration effects, Vibration frequencies, Human response, Visual performance

A series of experiments to determine the effects of vibration frequency, viewing distance and multiple frequency motions on the reading of numeric characters is described. Contours of vertical whole-body vibration levels resulting in equal degradation of the reading task were determined over the frequency range 2·8 Hz to 63 Hz.

MECHANICAL COMPONENTS

ABSORBERS AND ISOLATORS

(Also see Nos. 26, 146, 182, 213, 214)

81-54
Auxiliary Mass Throw in a Tuned and Damped Vibration Absorber
A.G. Thompson

Dept. of Mech. Engrg., The Univ. of Adelaide, Adelaide, South Australia 5001, J. Sound Vib., 70 (4), pp 481-486 (June 22, 1980) 4 figs, 3 refs

Key Words: Dynamic vibration absorption (equipment)

Dynamic vibration absorbers should be tuned and optimally damped to control the amplitudes of vibration of the primary mass over the whole range of exciting frequencies. The lighter the auxiliary mass the greater is the amplitude of its excursions relative to the primary mass. In the case of a tuned system the maximum steady state throw of the auxiliary mass can be easily calculated from the formulas given. These are derived by use of a frequency locus technique.

81-55

Systems for Noise and Vibration Control

W.E. Purcell

S/V, Sound Vib., 14 (6), pp 10-36 (Aug 1980) 55 figs

Key Words: Noise reduction, Vibration control, Acoustic absorbers, Noise barriers, Silencers

A comprehensive mini-handbook for the selection and application of commonly available noise and vibration control systems is compiled. Basic information is provided on the characteristics of sound absorptive systems, sound barrier systems, silencers, and vibration/shock control systems.

81-56

Ring-Loaded Flexural Disc Spring

T.D. Sullivan

Dept. of the Navy, Washington, D.C., U.S. PATENT-4 196 895, 5 pp (Apr 1980)

Key Words: Vibration isolators, Disk springs, Sound transducers, Underwater structures

A ring-loaded flexural disc spring acts as an isolation mount in a thin cylindrical space in the tail of a longitudinal vibrator type of underwater sound transducer. The ring-loaded spring comprises a thin disc having a raised bearing surface at a specified distance from the perimeter on one side of the disc and a raised bearing surface at the perimeter on the other side of the disc. The spring flexes into a concave shape when a load is applied. The operation of the disc is linear over the entire specified load range.

81-57

Scraper Suspension Acts like a Variable-Rate Spring

J.A. Bednar

Engrg. & Res. Dept., Terex Div., General Motors Corp., Hudson, OH, Hydraulics & Pneumatics, 33 (8), pp 59-62 (Aug 1980) 5 figs

Key Words: Suspension systems (vehicles), Construction equipment

A new hydrodynamic suspension on the front axle of the TS-24B Roadrunner scraper is described which enables the front axle to absorb road shock, reduce scraper lope or bobbing, and, consequently, reduce cycle time on many jobs. The suspension also reduces shock transmitted to the frame by absorbing shock forces before they reach the frame, thus improving the structural reliability of the scraper.

81-58

Viscoelastic Modeling of Rubber Type Torsional Elements under Creep and Impulsive Loading Conditions

I.-F. Lin and A. Seireg

Mechanical Engrg. Dept., Univ. of Wisconsin-Madison, Madison, WI, Reliability, Stress Analysis and Failure Prevention Methods in Mechanical Design, Intl. Conf., Aug 18-21, 1980, San Francisco, CA, W.D. Milestone, ed.; ASME: 1980, pp 305-311, 13 figs, 3 tables, 15 refs

Key Words: Elastomers, Viscoelastic properties, Impact response (mechanical)

Modeling viscoelastic behavior of rubber or polymer type cylindrical torsional elements under sustained uniform loads as well as impulsive load conditions is studied. Series of experiments run at different temperatures are utilized in developing the models.

81-59

First Order Dynamic Response of Freight Car to Track Irregularities

S.G. Guins

Transportation Consultant Pueblo West, CO 81007, J. Engr. Indus., Trans. ASME, 102 (3), pp 258-262 (Aug 1980) 15 figs, 4 refs

Key Words: Railroad cars, Freight cars, Suspension systems (vehicles), Track roughness

A review of simple dynamic response of the freight car suspension to track irregularities, the resultant effect on lading and energy feedback to the track structure, is presented.

81-60

A Trilinear Base-Isolator Concept for Nuclear Power Plants

P. Varpasuo, K. Raty, and J. Kenttala
Imatran Voima Oy, Civil Engrg. Dept., SF-00101 Helsinki, 10, Finland, Nucl. Engr. Des., 58 (3), pp 437-448 (June 1980) 9 figs, 8 refs

Key Words: Seismic isolation, Nucle .r power plants

A friction limited base-isolation concept for moderate seismicity areas is presented. The idea of the concept is to combine frictional damping with base-isolation. The aim of the design effort is to develop a system whose stiffness and damping characteristics are selected to optimize the operational properties of the isolator device for the given site conditions, so that most favorable combination of acceleration and displacement responses of the system is achieved.

SPRINGS

81-61

Measurement and Representation of the Mechanical Properties of Truck Leaf Springs

P.S. Francher, R.D. Ervin, C.C. MacAdam, and C.B. Winkler
Highway Safety Res. Inst., The Univ. of Michigan, SAE Paper No. 800905, 16 pp, 14 figs, 1 table, 3 refs

Key Words: Suspension systems (vehicles), Leaf springs, Trucks

The force-versus-deflection properties of truck leaf springs are studied with respect to the influences of motion amplitude and frequency (0 to 15 Hz) upon hysteretic damping and effective spring rate. Measurements showing the influence of the amplitude of stroking are analyzed for five representative examples of currently employed leaf springs. A mathematical method for representing the force-versus-deflection characteristics of leaf springs is presented in a form suitable for use in digital simulations of vehicle dynamics.

81-62

Charts Simplify Torsion Spring Design

Design Engineering, pp 61-64 (Sept 1980) 5 figs

Key Words: Springs, Torsion bars, Design techniques

A series of charts for stress range and spring index range are summarized. They were developed as aids in the design of torsional springs. The charts show how the spring factors affect each other with each change, and how to optimize final decisions.

TIRES AND WHEELS

81-63

Calculation of Natural Frequencies and Modes of Tires in Road Contact by Utilizing Eigenvalues of the Axisymmetric Non-Contacting Tire

W. Soedel and M.G. Prasad
Ray W. Herrick Labs., School of Mech. Engrg., Purdue Univ., West Lafayette, IN 47907, J. Sound Vib., 70 (4), pp 573-584 (June 22, 1980) 7 figs, 5 tables, 15 refs

Key Words: Tires, Natural frequencies, Mode shapes

Given the experimental or theoretical natural frequencies and modes of a tire mounted and inflated, but not in ground contact, an analytical method is presented that allows one to obtain the natural frequencies and modes when this tire is in ground contact. This is of practical advantage since measurements or calculations of the free axisymmetric tire are considerably simpler than directly measuring or analyzing the non-axisymmetric case of ground contact.

81-64

Dynamic Behavior and Residual Stresses in Railroad Wheels

G.F. Carpenter, J.M. Wandrisco, and D.E. Sonon
Res. Lab., U.S. Steel Corp., Monroeville, PA, Rept. No. FRA/ORD-78/54, 85 pp (Apr 1980)
PB80-194897

Key Words: Wheels, Railroad cars, Freight cars, Fatigue life

A study of the dynamic behavior and residual stresses in straight-plate and curved-plate 33-inch-diameter one-wear freight-car wheels is conducted. The data developed in this study, in conjunction with additional data to be developed in the overall program, can be used to verify finite-element computer programs and to conduct detailed analyses of the resistance of various wheels to fatigue failure.

81-65

Improved Wheel Tread Profiles for Heavy Freight Vehicles

P.P. Marcotte, K.J.R. Mathewson, W.N. Caldwell

Canadian National Railways, CN Rail Res. Ctr., Montreal, Quebec, Canada, J. Engr. Indus., Trans. ASME, 102 (3), pp 263-271 (Aug 1980) 12 figs, 1 table, 18 refs

Key Words: Wheels, Railroad cars, Freight cars, Interaction: rail-wheel

Recent theoretical and experimental work carried out in an effort to improve the performance of conventional 100-ton freight car trucks through the use of nonstandard wheel tread profiles is described. The steady state curving behavior of a conventional three-piece frame truck is studied using a nonlinear computer simulation to identify the effects of wheel conicity and track curvature on wheel-rail forces and on wear parameters.

BLADES

(Also see Nos. 91, 189, 212)

81-66

Interferometrically Measured Aerodynamic Forces on a Vibrating Turbine Blade Group

Z. Kovats

Mechanics Dept., Westinghouse Electric Corp., Res. and Dev. Ctr., Pittsburgh, PA 15235, J. Lubric. Tech., Trans. ASME, 102 (3), pp 638-645 (July 1980) 16 figs, 1 ref

Key Words: Blades, Turbine blades, Aerodynamic loads, Flutter, Interferometric techniques

The instantaneous aerodynamic force and force center during a vibration cycle were determined from interferometrically measured pressure distributions around the leading blade of a low pressure turbine blade group vibrating in the tangential, axial or twist modes. The energy exchange per vibration cycle between the air flow and the leading blade of a group, and the lift and drag dynamic loops were determined for each of the three vibration modes.

81-67

Thermal Stress and Gas Bending Effects on Vibration of Compressor Rotor Stages

L. Chen and J. Dugundji

Massachusetts Inst. of Tech., Cambridge, MA, J. Aircraft, 17 (8), pp 576-583 (Aug 1980) 9 figs, 3 tables, 9 refs

Key Words: Rotating structures, Blades, Compressor blades, Thermal excitation

The effects of transient thermal stresses and steady-state gas bending loads on the vibration of a rotating, pretwisted compressor blade and the effect of thermal stresses on the vibration of a rotating compressor disk were studied.

81-68

Linear-Nonlinear Interface for Finite Element Transient Impact Damage Analysis

K.W. Brown

Ph.D. Thesis, Rensselaer Polytechnic Inst., 105 pp (1980)

UM 8020397

Key Words: Fan blades, Impact response (mechanical), Finite element technique

A nonlinear transient finite element structural model is interfaced with a linear finite element representation. The new analysis technique, which allows local nonlinear modeling of a predominantly linear structural response, is shown to be particularly applicable to impact damage analysis of jet engine fan blades, due to the relatively local nature of blade nonlinear response to impact events, coupled with the large area where linear theory is sufficient for blade impact response definition.

BEARINGS

(Also see Nos. 176, 204, 209)

81-69

Stability and Transient Characteristics of Four Multilobe Journal Bearing Configurations

D.F. Li, K.C. Choy, and P.E. Allaire

Dept. of Mech. and Aerospace Engrg., School of Engrg. and Applied Science, Univ. of Virginia, Charlottesville, VA 22901, J. Lubric. Tech., Trans. ASME, 102 (3), pp 291-299 (July 1980) 6 figs, 25 refs

Key Words: Bearings, Journal bearings, Rigid rotors, Rotors (machine elements), Fast Fourier transform

The linearized stability threshold of four multilobe journal bearings – elliptical, offset elliptical, three lobe, and four lobe – is analyzed. A nonlinear transient analysis of a rigid rotor in each of these bearings is carried out above and below the threshold speed. Shaft orbits and bearing forces are calculated. A numerical fast Fourier transform analysis is used to obtain the frequency content of the nonlinear orbit.

81-70

Hydrodynamic Stiffness and Damping of Ship's Thrust Bearings (Untersuchungen über die hydrodynamische Steifigkeit und Dämpfung von Schiffsdrucklagern)

H. Schwanecke

VDI-2, 122 (14), pp 605-611 (July 1980) 12 figs, 5 refs

(In German)

Key Words: Bearings, Thrust bearings, Lubrication, Dynamic stiffness, Vibration damping, Ships

During a trial run of a container ship the longitudinal vibrations of the transmission shaft of its 26,000 kW drive system were measured. A mathematical model of the system was used for the investigation of the thrust bearings and compared with the experimental results. It was shown that in the range of mechanical resonances the response of the oil film in the thrust bearings is strongly nonlinear, which results in a considerable reduction of hydrodynamic stiffness and damping. It was also found, that even outside the resonance range, the dynamic load capacities of thrust bearings assume proportionally small values, which decrease further with increasing load frequencies.

81-71

A Finite Length Bearing Correction Factor for Short Bearing Theory

L.E. Barrett, P.E. Allaire, and E.J. Gunter

Dept. of Mech. and Aerospace Engrg., School of Engrg. and Applied Science, Univ. of Virginia, Charlottesville, VA 22901, J. Lubric. Tech., Trans. ASME, 102 (3), pp 283-290 (July 1980) 8 figs, 1 table, 15 refs

Key Words: Bearings, Hydrodynamic excitation, Squeeze film dampers

A rapid method for calculating the general nonlinear response of finite-length plain journal and squeeze film damper bearings is presented. The method incorporates a finite-length correction factor which modifies the nonlinear forces obtained from short bearing theory.

81-72

Journal Bearing Design for High Speed Turbomachinery

P.E. Allaire and R.D. Flack

Dept. of Mech. and Aerospace Engrg., Univ. of Virginia, Charlottesville, VA, Bearing Design - Historical Aspects, Present Technology and Future Problems. Intl. Conf., Aug 18-21, 1980, San Francisco, CA, W.J. Anderson, ed., ASME: 1980, pp 111-159, 30 figs, 9 tables, 13 refs

Key Words: Bearings, Journal bearings, Turbomachinery, Design techniques

A wide variety of bearings have been developed to combat some of the different types of vibration problems. The geometry, theoretical, and experimental results which have been obtained for a number of bearing types are discussed. A bearing summary chart indicating some of the advantages and disadvantages of these bearing types as well as others is included.

81-73

Analysis of Dynamically Loaded Floating-Ring Bearings for Automotive Applications

S.M. Rohde and H.A. Ezzat

Mech. Res. Dept., General Motors Res. Labs., Warren, MI 48090, J. Lubric. Tech., Trans. ASME, 102 (3), pp 271-277 (July 1980) 5 figs, 9 refs

Key Words: Bearings, Journal bearings, Floating ring journal bearings, Motor vehicle engines

The frictional performance of dynamically loaded floating-ring journal bearings is studied and their feasibility for automotive applications is investigated. The potential contribution of the floating-ring design concept to reduced engine friction is assessed, and its compliance with current bearing durability criteria is evaluated.

81-74

Behavior of Finite Journal Bearings under Dynamic Loading Conditions

G.S.A. Shawki, M.O.A. Mokhtar, and Z.S. Safar
Mechanical Design Dept., Cairo Univ., Cairo, Egypt,
J. Lubric. Tech., Trans. ASME, 102 (3), pp 333-340 (July 1980) 12 figs, 42 refs

Key Words: Bearings, Journal bearings, Computer programs

Performance characteristics for a complete journal bearing of finite axial length are obtained analytically using a new set of boundary conditions. The generalized Reynolds equation is transformed into three ordinary differential equations, two of which being readily integrable while the third is solved by variational methods. By the aid of a specially devised computer program, the validity of the analysis has been assured when applied to prescribed journal loci including stationary, circular, elliptical, and linear harmonic journal oscillation.

81-75

An Improved Short Bearing Analysis for the Submerged Operation of Plain Journal Bearings and Squeeze-Film Dampers

C.H.T. Pan
Shaker Res. Corp., Ballston Lake, NY 12019,
J. Lubric. Tech., Trans. ASME, 102 (3), pp 320-332 (July 1980) 16 figs, 16 refs

Key Words: Bearings, Journal bearings, Vibration damping, Squeeze-film dampers

By allowing the film pressure to assume some subambient value and by allowing natural boundaries of the film to form in the unloaded region, the short-bearing theory of Ocvirk and Dubois is extended to include a detailed description of the cavitation zone. Two alternative cavitation configurations are shown to be possible, rendering different eccentricity and attitude angle for the same load and minimum film pressure.

81-76

Transient Unbalance Response of Four Multilobe Journal Bearings

P.E. Allaire, D.F. Li, and K.C. Choy
Dept. of Mech. and Aerospace Engrg., Univ. of Virginia, Charlottesville, VA 22901,
J. Lubric. Tech., Trans. ASME, 102 (3), pp 300-307 (July 1980) 8 figs, 19 refs

Key Words: Bearings, Journal bearings, Unbalanced mass response

The transient response of four multilobe journal bearings (elliptical, offset, three-lobe, and four-lobe) subject to unbalance both below and above the linearized stability thresholds for the bearings is analyzed. Transient orbits, bearing forces, and a numerical fast Fourier transfonn analysis of the orbits are presented.

81-77

Spherical Bearings: Static and Dynamic Analysis via the Finite Element Method

P.K. Goenka and J.F. Booker
School of Mechanical and Aerospace Engrg., Cornell Univ., Ithaca, NY 14853,
J. Lubric. Tech., Trans. ASME, 102 (3), pp 308-319 (July 1980) 15 figs, 4 tables, 14 refs

Key Words: Bearings, Spherical bearings, Finite element technique

The finite element method presented here can be used to analyze virtually any spherical bearing having an incompressible lubricant between surfaces which are smooth, rigid, and impermeable. The method can be easily extended to account for permeable surfaces and lubricants with variable viscosity and density.

81-78

Dynamic Characteristics of Aerostatic Thrust Bearings with Porous Inserts

B.C. Majumdar
Indian Inst. of Tech., Kharagpur, India,
J. Mech. Engr. Sci., 22 (2), pp 55-58 (Apr 1980) 5 figs, 2 tables, 5 refs

Key Words: Bearings, Thrust bearings, Rigid inclusion-containing media, Discontinuity-containing media, Perturbation theory

A first-order perturbation method is adopted to find the dynamic behavior of an aerostatic circular thrust bearing having a central porous insert as a restrictor. The linearized gas film stiffness and damping are derived and used to study their behavior with other design variables.

81-79

Fluid-Film Bearing Response to Dynamic Loading

W. Shapiro

Mechanical Technology Inc., Latham, NY, Bearing Design - Historical Aspects, Present Technology and Future Problems. Intl. Conf., Aug 18-21, 1980, San Francisco, CA, W.J. Anderson, ed.; ASME: 1980, pp 187-212, 16 figs, 15 refs

Key Words: Bearings, Fluid-film bearings, Dynamic response

Fluid-film bearings are often subjected to dynamic loads of sufficient magnitude to cause large variations in film thickness. Analysis of bearing performance under these conditions requires a nonlinear, forward integration in time approach which traces a time history of the motions of the bearing system under the subjected loading. This paper discusses numerical techniques, presents several examples, and makes suggestions for future development.

81-80

Computerized Analysis and Design Methodology for Rolling Element Bearing Load Support Systems

J. Pirvics

SKF Industries, Inc., King of Prussia, PA, Bearing Design - Historical Aspects, Present Technology and Future Problems. Intl. Conf., Aug 18-21, 1980, San Francisco, CA, W.J. Anderson, ed.; ASME: 1980, pp 47-85, 10 figs, 49 refs

Key Words: Bearings, Antifriction bearings, Computer-aided techniques, Design techniques

The evolution of computerized rolling element bearing analysis is reviewed. Load support system software structure is discussed in detail.

FASTENERS

(See No. 184)

VALVES

81-81

Dynamic Effects on Structures and Equipment Due to Safety Relief Valve Discharge Loads

C.M. Jan

Gibbs and Hill, Inc., New York, NY 10001, Nucl. Engr. Des., 59 (1), pp 171-183 (July 1980) 14 figs, 1 table, 5 refs

Key Words: Valves, Nuclear reactors, Boiling water reactors, Containment structures, Steel, Dynamic structural analysis

Analytical models, procedure, and results of a sensitivity study performed to investigate how the Safety Relief Valves (SRV) response of the steel containment of a Boiling Water Reactor (BWR) Mark III plant is influenced by the high frequency energy or noise associated with the idealized bubble forcing function are presented. Various possible structural modifications to those plants already designed to have a steel containment are also presented and discussed with regard to minimizing the dynamic effects of SRV discharge loads. Special attention is given to the concept of filling concrete in the annulus between the steel containment and the shield building.

81-82

Acoustic Source Properties of Governor Valves

J.A. Chadha, D.E. Hobson, A. Marshall, and D.H. Wilkinson

Ontario Hydro, Toronto, Canada, Flow-Induced Vibration of Power Plant Components. The Pressure Vessels and Piping Conf., PVP No. 41, Aug 12-15, 1980, San Francisco, CA, M.K. Au-Yang, ed., ASME: 1980, pp 125-138, 11 figs, 7 refs

Key Words: Valves, Noise generation, Noise source identification

Experimental and theoretical studies performed to characterize the overall acoustic source properties of governor valves are described. The test rig, the associated instrumentation, the theoretical model for the passive circuit acoustics, and the statistical analysis model for the determination of the acoustic source associated with the governor valve model provide satisfactory results. The limitations of the acoustic source measurement technique and areas requiring further development are identified.

STRUCTURAL COMPONENTS

CABLES

81-83

Forced Vibrations of Cable Networks

L.F. Geschwindner, Jr. and H.H. West

The Pennsylvania State Univ., University Park, PA, ASCE J. Struc. Div., 106 (ST9), pp 1885-1898 (Sept 1980) 11 figs, 2 tables, 14 refs

Key Words: Cables (ropes), Forced vibration

Forced vibration response is investigated for hyperbolic paraboloid cable networks composed of a linkage of straight members connected by frictionless pins with concentrated masses lumped at the connection points. The dynamic response through both a linear and a nonlinear formulation is evaluated and the responses are compared and conclusions drawn regarding the extent to which the nonlinear aspects of the structural response must be considered.

81-84

Natural Vibrations of Suspended Cables with Flexible Supports

G. Rega and A. Luongo

Istituto di Scienza delle Costruzioni, Universita dell' Aquila, L'Aquila 67100, Italy, Computers Struc., 12 (1), pp 65-75 (July 1980) 10 figs, 11 refs

Key Words: Cables (ropes), Suspended structures, Natural frequencies, Finite difference theory

A finite difference algorithm is applied to the study of in-plane natural vibrations of an inextensible cable with symmetric movable supports. Attention is given mainly to the analysis of the influence of support flexibility on the dynamic phenomenon. Several parametric studies are carried out and the analogy between the two cable models with lumped or distributed flexibility is shown.

81-85

A Random Vibration Model for Cable Strumming Prediction

M. Kennedy and J.K. Vandiver

Dept. of Ocean Engrg., Massachusetts Inst. of Tech., Cambridge, MA, 20 pp (1979)

AD-A083 774/0

Key Words: Cables (ropes), Vortex-induced vibration

A random vibration predictive model for cable strumming response to ocean currents is presented. The model is justified on the basis of an extensive examination of four different field experiments, conducted for the purpose of studying vortex induced cable vibration.

BARS AND RODS

81-86

Interfacial Elastic Parameters in Torsional Vibrations of a Periodic Structured Cylindrical Rod

R.P. Shaw and R.K. Kaul

Dept. of Engrg. Science, Aerospace Engrg. and Nuclear Engrg., SUNY at Buffalo, Buffalo, NY 14214, Intl. J. Solids Struc., 16 (9), pp 777-783 (1980) 1 fig, 3 refs

Key Words: Rods, Torsional vibrations, Elastic properties

A method is developed for qualitatively sketching the frequency spectrum of torsional waves propagating in a solid cylinder with periodic structure. This method introduces an interfacial elastic parameter, analogous to an impedance, which simplifies the problem considerably.

BEAMS

(Also see No. 184)

81-87

The Vibration of a Generalized Tuning Fork

M. Brannigan

National Res. Inst. for Mathematical Sciences, Council for Scientific and Industrial Res., Pretoria 0001, Rep. of South Africa, J. Sound Vib., 69 (3), pp 477-485 (Apr 8, 1980) 3 figs, 9 refs

Key Words: Beams, Curved beams, Natural frequencies

An analysis is made of the modes of vibration of, and the forces acting on, a symmetric thin-beam structure clamped at a point on the line of symmetry. The force at the fixed point is found when the structure is vibrating in its first mode and the results provide guide-lines for minimizing this force.

81-88

A Discrete Model for Dynamic Analysis of Ideal Fibre-Reinforced Rigid Plastic Beams

F. Laudiero

Istituto di Scienza delle Costruzioni, Facolta di Ingegneria, Bologna, Italy, Intl. J. Mech. Sci., 22 (7), pp 447-453 (1980) 6 figs, 11 refs

Key Words: Beams, Fiber composites, Dynamic plasticity, Dynamic buckling

A numerical procedure is developed for the dynamic plastic analysis of ideal fibre-reinforced beams with any given load and boundary condition. The numerical results are in good agreement with the theoretical predictions for those cases whose solutions are already known.

81-89

Vibration with "Dynamic Friction"

G.S. Whiston
Central Electricity Res. Labs., Kelvin Avenue, Leatherhead KT22 7SE, UK, J. Sound Vib., 69 (3), pp 395-404 (Apr 8, 1980) 6 figs, 5 refs

Key Words: Beams, Friction damping, Harmonic excitation, Periodic response

The free and harmonically forced vibration of an idealized straight beam oscillating in its fundamental mode with frictional clamps at each end is modeled by using a singular differential equation. Locking and chatter phenomena are analyzed and slipping motions integrated for the free system and the continuously slipping steady state response to harmonic excitation is qualitatively discussed.

81-90

An Improved Dynamic Numerical Analysis of Crack Initiation Fast Crack Propagation and Crack Arrest in the DCB Specimen

M. Perl
Dept. of Mech. Engrg., Univ. of Washington, Seattle, WA, Emerging Technologies in Aerospace Structures, Design, Structural Dynamics and Materials. Aerospace Conf., Aug 13-15, 1980, San Francisco, CA, J.R. Vinson, ed., ASME: 1980, pp 273-283, 14 figs, 2 tables, 18 refs

Key Words: Beams, Cantilever beams, Crack propagation, Numerical analysis

The problem of crack initiation, fast crack propagation and crack arrest in the double cantilever beam specimen is investigated within the confines of two-dimensional linear elastic fracture mechanics. The analysis is performed using the SMF2D code which is based upon the simultaneous employment of a static and dynamic coordinate system, thus providing a continuous and smoother crack extention.

81-91

A Note on the Equations of Motion for the Transverse Vibration of a Timoshenko Beam Subjected to an Axial Force

C.J. Norwood, N.J. Cubitt, and B. Downs
Dept. of Mech. Engrg., Univ. of Tech., Loughborough LE11 3TU, UK, J. Sound Vib., 70 (4), pp 475-479 (June 22, 1980) 1 fig, 5 refs

Key Words: Beam., Timoshenko theory, Axial excitation, Flexural vibration, Rotor blades (turbomachinery)

The equations of motion are derived for a Timoshenko beam of arbitrary section in transverse vibration with an applied axial loading. Some discrepancies are noted by comparison with earlier work and these are examined and accounted for. The application of these more general equations is then considered for certain special cases, including a rotating blade.

81-92

Vibration and Stability of a Non-Uniform Timoshenko Beam Subjected to a Follower Force

T. Irie, G. Yamada, and I. Takahashi
Dept. of Mech. Engrg., Hokkaido Univ., Sapporo 060, Japan, J. Sound Vib., 70 (4), pp 503-512 (June 22, 1980) 5 figs, 1 table, 16 refs

Key Words: Beams, Variable cross-section, Timoshenko theory, Follower forces, Transfer matrix method, Flutter, Natural frequencies

An analysis is presented for the vibration and stability of a non-uniform Timoshenko beam subjected to a tangential follower force distributed over the center line by use of the transfer matrix approach.

81-93

A Technical Theory of Dynamical Torsion for Beams of any Cross-Section Shapes

D. Gay and R. Boudet
Department de Mecanique, Institut National des Sciences Appliquees, Toulouse, Cerdex, France, J. Mech. Des., Trans. ASME, 102 (3), pp 627-632 (July 1980) 2 figs, 13 refs

Key Words: Beams, Torsional vibration

In order to study the free torsional oscillations of beams, two parameters are introduced - a torsion parameter and a warping parameter - each of them by means of a statistical definition. Using the classical hypothesis of strength of materials, the dynamical comportment of the beam is reduced to a one-dimensional comportment. The four basic relations obtained present a similar form with those of bending motion of a Timoshenko beam. Hence equation of torsional motion is derived and usual cases of boundary conditions relevant to the problem are given.

81-94

Bending Vibrations of Rotating Homogeneous Satellite Booms with Time Dependent Boundary Conditions (Biegeschwingungen von homogenen um die Achse rotierenden Satellitenauslegern mit zeitlich veränderlichen Randbedingungen)

H.F. Bauer
Hochschule der Bundeswehr München, Munich, Germany, Z. Flugwiss, 4 (3), pp 121-128 (May/June 1980) 3 figs, 1 table, 5 refs
(In German)

Key Words: Spacecraft antennas, Rotating structures, Flexural vibrations, Time-dependent excitation

A method is presented for the determination of the vibrational behavior of satellite booms with time varying boundary conditions and rotation about their longitudinal axis. The method is exhibited at rotating satellite booms with and without endmasses, of which the clamped-in position performs an arbitrary motion.

CYLINDERS

81-95

A Mechanism for Parallel Flow-Induced Vibrations

Y.T. Fung
Nuclear Energy Engrg. Div., General Electric Co., San Jose, CA, Flow-Induced Vibration of Power Plant Components. The Pressure Vessels and Piping Conf., PVP No. 41, Aug 12-15, 1980, San Francisco, CA, M.K. Au-Yang, ed., ASME: 1980, pp 65-76, 7 figs, 16 refs

Key Words: Cylinders, Fluid-induced excitation

Vibration characteristics of a cylindrical structure subject to turbulent parallel flows are investigated. Pressure fluctuations from external flows on the surface of the cylinder provide the lateral forces for oscillation motion. Homogeneity of the fluctuating pressure in the turbulent boundary layer of the cylinder is assumed. A mechanism based on a time scale, namely the azimuthal time delay resulting from the small scale nonaxisymmetric perturbations to the pressure field, is proposed. This mechanism is based on the propagation of pressure fronts with the characteristic azimuthal time delay playing an important role in the degree of lateral force concentration, and therefore, in the flow-induced oscillation of the cylinder.

81-96

Unsteady Fluid Dynamic Force on Tube Bundle and Its Dynamic Effect on Vibration

H. Tanaka and S. Takahara
Nagasaki Technical Inst., Technical Headquarters, Mitsubishi Heavy Industries, Ltd., Nagasaki, Japan, Flow-Induced Vibration of Power Plant Components. The Pressure Vessels and Piping Conf., PVP No. 41, Aug 12-15, 1980, San Francisco, CA, M.K. Au-Yang, ed., ASME: 1980, pp 77-92, 25 figs, 2 tables, 11 refs

Key Words: Tubes, Cylinders, Fluid-induced excitation

Unsteady fluid dynamic forces acting on vibrating cylinder bundles are considered. The unsteady fluid dynamic forces comprise the inertia forces due to the added mass of fluid, damping forces of fluid in phase to the cylinder vibrating velocity, and stiffness forces proportional to cylinder displacements. Considering the influences of neighboring cylinder vibrations, ten kinds of unsteady fluid dynamic forces are considered to act on a cylinder in a cylinder bundle. Model tests were conducted to measure the forces.

COLUMNS

81-97

A Nondestructive Dynamic Method for the Determination of the Critical Load of Elastic Columns

A. Segall and M. Baruch
Dept. of Aeronautical Engrg., Technion, Haifa, Israel, Exptl. Mech., 20 (8), pp 285-288 (Aug 1980) 4 figs, 2 tables, 12 refs

Key Words: Columns, Dynamic buckling, Integral equations

A dynamic method for predicting the buckling load of an elastic column is formulated based on the integral-equation representation of a column with varying cross section and elastic springs at the boundaries. The experimental inputs are the dynamic properties of the unloaded column (frequencies, mode shapes and masses).

PANELS

81-98

Noise Transmission Through Stiffened Panels

R. Vaicaitis and M. Slazak
Dept. of Civil Engrg. and Engrg. Mechanics, Columbia Univ., New York, NY 10027, J. Sound Vib., 70 (3), pp 413-426 (June 8, 1980) 13 figs, 1 table, 27 refs

Key Words: Panels, Stiffened panels, Enclosures, Noise transmission, Transfer matrix method

An analytical study is presented to predict low frequency noise transmission through finite stiffened panels into rectangular enclosures. Noise transmission is determined by solving the acoustic wave equation for the interior noise field and stiffened panel equations for vibrations of panels and stringers. Results include a comparison between theory and experiment and noise transmission through the sidewall of an aircraft.

PLATES

81-99

Stability and Vibration of an Annular Plate with Concentrated Edge Load

V. Srinivasan and V. Ramamurti
Indian Inst. of Tech., Madras-600036, India, Computers Struc., 12 (1), pp 119-129 (July 1980) 7 figs, 5 tables, 13 refs

Key Words: Plates, Annular discs, Finite element technique

Buckling and free vibration of an annular plate with clamped inner boundary and a concentrated, in-plane edge load at the outer boundary are studied using the semi-analytical finite element method. The annular plate elements developed by Pardoen are used for this purpose. Exact in-plane stress field is obtained for various harmonics. Geometric stiffness matrices are developed which are general and can handle any in-plane stress field once its Fourier expansion is known.

81-100

Transverse Vibration of Simply Supported Circular Plates Having Partial Elastic Constraints

Y. Narita and A.W. Leissa
The Ohio State Univ., Columbus, OH 43210, J. Sound Vib., 70 (1), pp 103-116 (May 8, 1980) 6 figs, 7 tables, 13 refs

Key Words: Plates, Circular plates, Elastically restrained edges, Flexural vibration

For the problem of the free vibration of a simply supported circular plate elastically constrained along part of the boundary, a series-type solution is derived by the extension of a previously developed method. In the numerical study, some uniform rotational springs are equally spaced along the circumference of the plate. The natural frequencies and nodal patterns for the lowest five modes are presented for a range of spring parameters. The effect of varying stiffness and angle of the springs is discussed.

81-101

Natural Frequencies of Simply Supported Circular Plates

A.W. Leissa and Y. Narita
Dept. of Engrg. Mechanics, Ohio State Univ., Columbus, OH 43210, J. Sound Vib., 70 (2), pp 221-229 (May 22, 1980) 1 fig, 10 tables, 11 refs

Key Words: Plates, Circular plates, Natural frequencies

Although the problem of finding the natural frequencies of free vibration of a simply supported circular plate has a straightforward solution, very few numerical results are available in the literature. In the present work accurate (six significant figure) non-dimensional frequency parameters are given.

81-102

Free Vibration of Some Circular Plates of Arbitrary Thickness

Z. Celep
Faculty of Engrg. and Architecture, Technical Univ., Istanbul, Turkey, J. Sound Vib., 70 (3), pp 379-388 (June 8, 1980) 6 figs, 10 refs

Key Words: Plates, Circular plates, Method of initial functions, Free vibration

A brief account of the construction technique of the method of initial functions which has been developed for circular plates is given. The new method is applied to investigate the free vibration of two circular plates: i.e., simply supported and completely free plates.

81-103

IN SITU Determination of Loss and Coupling Loss Factors by the Power Injection Method

D.A. Bies and S. Hamid

Dept. of Mech. Engrg., Univ. of Adelaide, Adelaide, South Australia 5000, J. Sound Vib., 70 (2), pp 187-204 (May 22, 1980) 11 figs, 15 refs

Key Words: Plates, Coupled systems, Energy dissipation

Vibrational energy distribution between two coupled plates is considered. Inversion of the linear power balance equations is used to determine the plate loss factors and the coupling loss factors in situ. Good agreement is obtained between the predicted and measured coupling loss factors and between the in situ loss factors and loss factors determined for each plate separately also in steady state from power injection measurements.

81-104

Transmission of Reverberant Sound Through Orthotropic, Viscoelastic Multilayered Plates

J.L. Guyader and C. Lesueur

Vibration-Acoustics Lab. of the National Inst. of Applied Sciences, 69621 Villeurbanne, Cedex, France, J. Sound Vib., 70 (3), pp 319-332 (June 8, 1980) 12 figs, 1 table, 14 refs

Key Words: Plates, Layered materials, Sound transmission, Orthotropism, Viscoelastic properties

An extension of the study of acoustic transmission through orthotropic multilayered plates under oblique plane wave excitation to the case of reverberant sound excitation is reported. In order to compute the mean transmission loss over the wave incidence angles an analytical method is adopted, rather than the classical double integral calculation which is very cumbersome. The influences of layering, damping, and orthotropy are discussed. A comparison between theoretical and experimental results is presented.

81-105

Displacement Field of an Insonified Thick Elastic Plate

G.G. Swinerd and A. Freedman

Dept. of Mathematics, Univ. of Dundee, Dundee DD1 4HN, Scotland, J. Sound Vib., 70 (2), pp 231-266 (May 22, 1980) 17 figs, 1 table, 9 refs

Key Words: Plates, Acoustic excitation, Displacement measurement

The displacement field engendered within an infinite, water-immersed, steel plate, 0·55 shear wavelengths thick, by insonification by a plane wave at arbitrary incidence angle, was examined in a previous paper. For that plate the evolution of the interior field with increase of incidence angle from near normal incidence to near grazing incidence was investigated and related to the characteristics of the plate's reflection and transmission coefficients. The behavior was shown to be especially influenced by the three Lamb modes which can be excited for that plate thickness. A report on a similar investigation for a plate thickness of 2·5 shear wavelengths, at which thickness nine Lamb modes can be excited, with consequent increase in the complexity of the evolution of the interior and exterior fields is presented. Diagrams are presented illustrating in detail this evolution of the plate's displacement field, and explanations for the complex changes of structure with incidence angle are provided.

81-106

Sound Transmission at the Corner of Concrete Plates

J.C. Davies and B.M. Gibbs

Dept. of Construction and Environmental Health, The Univ. of Aston in Birmingham, Gosta Green, Birmingham, UK, Acustica, 45 (1), pp 39-45 (May 1980) 11 figs, 11 refs

Key Words: Plates, Concrete, Sound transmission

A description is given of initial investigations into bending waves generated at the junction of two concrete plates as a result of an incident bending wave.

81-107

High Frequency Vibrations of Quartz Plates by Expansion in Series of Ekstein Functions

R.D. Mindlin

89 Deer Hill Drive, Ridgefield, CT 06877, Intl. J. Solids Struc., 16 (9), pp 785-791 (1980) 1 fig, 8 refs

Key Words: Plates, Quartz resonators, High frequency response

A solution is presented for high frequency vibrations of anisotropic, elastic plates applicable to rotated-Y-cuts of quartz with a pair of free edges. The solution is based on an expansion in a series of Ekstein's exact, nomial functions for the infinite plate - retaining the first three terms: flexure, thickness-shear, face-shear.

81-108

Impact Noise Transmission by a Three-Layered Structure Influence of the Characteristics of the Tapping Machine (Transmission des bruits d'impact par une structure a trois couches - Influence des caracteristiques de la machine a chocs)

H. Devaux, C. Boisson, and C. Lesueur

Laboratoire Vibrations-Acoustique, Bt 303 INSA Lyon, F-69621 Villeurbanne Cédex, France, Acustica, 45 (2), pp 77-86 (June 1980) 11 figs, 15 refs (In French)

Key Words: Plates, Rectangular plates, Noise transmission, Impact response (mechanical)

A calculation method is established for estimating the radiated noise level produced by a rectangular plate covered by two soft layers, when excited by mechanical impact. The hammer-structure contact is modeled by assuming a Hertzian contact and using the radiation coefficients calculated by Maidanik.

81-109

Rayleigh-Ritz Vibration Analysis of Mindlin Plates

D.J. Dawe and O.L. Roufaeil

Dept. of Civil Engrg., Univ. of Birmingham, Birmingham, B15 2TT, UK, J. Sound Vib., 69 (3), pp 345-359 (Apr 8, 1980) 1 fig, 12 tables, 14 refs

Key Words: Plates, Rayleigh-Ritz method, Natural frequencies, Flexural vibration, Transverse shear deformation effects, Rotatory inertia effects

The Rayleigh-Ritz method is applied to the prediction of the natural frequencies of flexural vibration of square plates having general boundary conditions. The analysis is based on the use of Mindlin plate theory so that the effects of shear deformation and rotary inertia are included.

81-110

Vibration and Buckling of Rectangular Plates under In-Plane Hydrostatic Loading

R.E. Kielb and L.S. Han

NASA Lewis Res. Ctr., Cleveland, OH 44135, J. Sound Vib., 70 (4), pp 543-555 (June 22, 1980) 14 figs, 3 tables, 15 refs

Key Words: Plates, Rectangular plates, Natural frequencies, Mode shapes

Numerical solutions are presented for the fundamental natural frequency and mode shape of a rectangular plate loaded by in-plane hydrostatic forces for a wide variety of aspect ratios, boundary conditions, and load magnitudes. All six possible combinations of simply supported and clamped edges are considered. The limiting conditions of unloaded vibration and buckling are discussed in detail, with emphasis on the preferred mode shape.

81-111

Flexural Vibrations of Annular Plates under Uniform In-Plane Compressive Forces

G.K. Ramaiah

Institut fur Mechanik, Technische Hochschule Darmstadt, D-6100, Darmstadt, West Germany, J. Sound Vib., 70 (1), pp 117-131 (May 8, 1980) 4 figs, 2 tables, 23 refs

Key Words: Plates, Annular discs, Flexural vibration, Rayleigh-Ritz method

The problem of free flexural vibrations of thin annular plates under uniform in-plane compressive forces along the inner and/or outer edges has been analyzed in detail by the Rayleigh-Ritz method for eight different combinations of clamped, simply supported and free edge support conditions. Accurate estimates of eigenfrequencies have been obtained for various values of hole sizes and load intensity ratios (actual load/critical buckling load) and for a wide range of circumferential wave number.

81-112

Prediction of the Change in Natural Frequency of a Cantilevered Flat Plate with Added Lumped Mass

P.W. Whaley

Dept. of Aeronautics and Astronautics, Air Force Inst. of Tech., Wright-Patterson Air Force Base, OH

45433, J. Sound Vib., 69 (4), pp 519-529 (Apr 22, 1980) 5 figs, 3 tables, 20 refs

Key Words: Plates, Cantilever plates, Natural frequencies, Vibration prediction, Airborne equipment response

An approximation technique for predicting the loaded airframe natural frequencies from the unloaded modes is presented. Accuracy of the predictions is greater than 10% for most loading configurations when compared to experimental measurements on a cantilevered plate. Accuracies greater than 20% were achieved for all configurations tested.

81-113

Bounds for Frequencies of Rib Reinforced Plates

D.W. Fox and V.G. Sigillito

Applied Physics Lab., The Johns Hopkins Univ., Laurel, MD 20810, J. Sound Vib., 69 (4), pp 497-507 (Apr 22, 1980) 2 figs, 4 tables, 6 refs

Key Words: Plates, Reinforced plates, Natural frequencies, Boundary value problems

Rigorous upper and lower bounds are presented for the frequencies of vibration of a thin elastic plate reinforced by an elastically attached rib. This study has two purposes: the first is to indicate how a method for lower bounds can be applied to simple built-up structures and the second is to demonstrate the effectiveness of the method in a relatively easy but useful application.

81-114

An Extended Transfer Matrix-Finite Element Method for Free Vibration of Plates

S. Sankar and S.V. Hoa

Dept. of Mech. Engrg., Concordia Univ., Montreal, Canada, J. Sound Vib., 70 (2), pp 205-211 (May 22, 1980) 2 figs, 2 tables, 9 refs

Key Words: Plates, Cantilever plates, Natural frequencies, Transfer matrix method, Finite element technique

A combination of extended transfer matrix and finite element methods is proposed for obtaining vibration frequencies of structures. This method yields the value of the frequency once a trial value is assumed. By using this technique, the number of nodes required in the regular finite element method is reduced and therefore a smaller computer can be used.

81-115

A Method for the Determination of the Fundamental Frequency of Orthotropic Plates of Polygonal Boundary Shape

P.A.A. Laura, L.E. Luisoni, and G.S. Sarmiento

Inst. of Applied Mechanics, 8111 Puerto Belgrano Naval Base, Argentina, J. Sound Vib., 70 (1), pp 77-84 (May 8, 1980) 2 figs, 3 tables, 9 refs

Key Words: Plates, Orthotropism, Fundamental frequency

A solution of the title problem is obtained by extending the approach suggested by Timoshenko in his classical vibrations textbook. Numerical results are presented for orthotropic clamped and simply supported plates of regular polygonal shape. For the isotropic case the results are in reasonably good agreement with values previously published in the technical literature.

81-116

Propeller Induced Hull Plate Vibrations

A.C. Nilsson

Det norske Veritas, Res. Div., N-1322 Hoevik, Norway, J. Sound Vib., 69 (4), pp 539-557 (Apr 22, 1980) 13 figs, 12 refs

Key Words: Plates, Ship hulls, Propeller-induced excitation, Fluid-induced excitation

The response of a fluid loaded plate is derived as function of the incident pressure in the fluid. The results are compared with full scale measurements made in the aft peak tank on a ship. Propeller induced pressure and hull plate velocity are measured with flush-mounted hydrophones and accelerometers.

81-117

The Dynamic Analysis of Circular Plates and Shallow Spherical Shells

R.S. Alwar and B. Sekhar Reddy

Dept. of Applied Mechanics, Indian Inst. of Tech., Madras 600 036, India, J. Sound Vib., 70 (4), pp 467-473 (June 22, 1980) 6 figs, 12 refs

Key Words: Plates, Shells, Spherical shells, Transient response

An attempt is made to study the influence of Berger's approximation on the non-linear transient response of circular plates and shallow spherical shells. The governing equations of motion obtained from Berger's approximation are solved by using the rapidly converging Chebyshev series space-wise and the Houbolt scheme for integration in the time domain. Results calculated when using Berger's approximation are compared with exact results.

SHELLS

(Also see No. 117)

81-118

Interior Noise Studies for Single- and Double-Walled Cylindrical Shells

E.H. Dowell

Princeton Univ., Princeton, NJ, J. Aircraft, 17 (9), pp 690-699 (Sept 1980) 10 figs, 4 tables, 13 refs

Key Words: Shells, Cylindrical shells, Interior noise, Aircraft

The modal theory of acoustoelasticity is applied to the determination of the sound levels caused by a prescribed external sound excitation which is transmitted through a cylindrical shell. A circumferential pseudo-traveling pressure wave excitation is studied as representative of a propeller sound field. It is shown how other excitations such as point mechanical loading, plane wave, and reverberation random may be synthesized by superposition of circumferential waves.

81-119

Dynamic Crack Propagation in Precracked Cylindrical Vessels Subjected to Shock Loading

C.H. Popelar, P.C. Gehlen, and M.F. Kanninen

Battelle Columbus Labs., OH, 9 pp (Aug 1979)

AD-A085 196/4

Key Words: Shells, Cylindrical shells, Crack propagation, Shock response

A speed-independent dynamic fracture toughness property can be used in an elastodynamic analysis to describe crack initiation and unstable propagation under impact loading. A further step is taken by extending the analysis from simple laboratory test specimens to treat more realistic crack-structure geometries. A circular cylinder with an initial part-through wall crack subjected to an impulsive loading on its inner surface is considered.

81-120

Extension of the Vaughan-Florence Analysis of Dynamic Buckling of a Rigid-Plastic Cylindrical Shell

G. Horvay and M.A. Veluswami

Dept. of Civil Engineering, Massachusetts Univ., Amherst, MA, 21 pp (1979)

COO-4122-28

Key Words: Shells, Cylindrical shells, Nuclear power plants, Nuclear reactor components, Dynamic buckling

Results of the HVS analysis based on the full equation are contrasted with those of the VF analysis, for a steel core support barrel representative of industrial nuclear power-plant practice. It is found that the decrease in criticality is not as spectacular as it is for the aluminum test shell of VF.

81-121

Dynamic Buckling of a Rigid-Plastic Cylindrical Shell: A Second Order Differential Equation Subject to Four Boundary Conditions

K. Zak, M.A. Veluswami, and G. Horvay

Massachusetts Univ., Amherst, MA, 23 pp (1979)

COO-4122-29

Microfiche copies only

Key Words: Shells, Cylindrical shells, Dynamic buckling, Power series method

Three methods of solution are considered: power-series expansion (in conjunction with Pade approximants); cosine-series solution, and its pair obtained by the variation of parameters method; and pseudo-Hill analysis.

81-122

Dynamic Buckling of Inelastic Spherical Shells

G.E. Funk

Ph.D. Thesis, Univ. of Notre Dame, 359 pp (1980)

UM 8020960

Key Words: Shells, Spherical shells, Dynamic buckling

The dynamic inelastic buckling of the complete spherical shell having mechanical properties characterized by a strain rate potential is investigated. Both bilinear elastic-plastic and Ramberg-Osgood uniaxial stress-strain relationships are considered. A minimum principle is employed to develop the equations of perturbed motion in functional form.

81-123
Nonlinear Dynamic Buckling of Spherical Caps with Initial Imperfections
R. Kao
Dept. of Civil, Mechanical and Environmental Engrg., George Washington Univ., Washington, D.C. 20052, Computers Struc., 12 (1), pp 49-63 (July 1980) 14 figs, 1 table, 22 refs

Key Words: Caps (supports), Shells, Spherical shells, Dynamic buckling, Finite difference theory

A finite difference method is developed for the large deformation elastic-plastic dynamic buckling analysis of axisymmetric spherical caps with initial imperfections. The problem formulation is based on governing differential equations of motion, treating the plastic deformation as an effective plastic load. Both perfectly plastic and strain hardening behavior are implemented in the program.

81-124
A New Frequency Formula for Closed Circular Cylindrical Shells for a Large Variety of Boundary Conditions
W. Soedel
School of Mech. Engrg., Purdue Univ., West Lafayette, IN 47907, J. Sound Vib., 70 (3), pp 309-317 (June 8, 1980) 5 figs, 1 table, 9 refs

Key Words: Shells, Circular shells, Cylindrical shells, Boundary condition effects, Natural frequencies

A new formula for the natural frequencies of circular cylindrical shells is presented for modes in which transverse deflections dominate. It is valid for all boundary conditions for which the roots of the analogous beam problem can be obtained. Good agreement with experimental data for a variety of boundary conditions is shown.

81-125
3-D Limit Load Analysis of Reinforced Concrete Shells of Arbitrary Shape
J.H. Coenen
Service de Mecanique des milieux continus, Institut des Constructions Civiles, Universite Libre de Bruxelles, Avenue A. Buyl, 87-1050 Bruxelles, Belgium, Computers Struc., 12 (1), pp 107-117 (July 1980) 17 figs, 27 refs

Key Words: Shells, Reinforced concrete, Limit analysis

A limit analysis method for thick reinforced concrete shells of arbitrary shape is developed using a 3-D concrete model based on a Mohr-Coulomb fracture theory in a solid-like isoparametric element. The proposed approach is well suited to engineering requirements as is illustrated by an HP shell case study.

81-126
Elasto-Visco-Plastic Dynamic Response of Axisymmetrical Shells by Overlay Model
S. Takezono, K. Tao and K. Kanezaki
Dept. of Mech. Engrg., Kumamoto Univ., Kurokami, Kumamoto, Japan, J. Pressure Vessel Tech., Trans. ASME, 102 (3), pp 257-263 (Aug 1980) 14 figs, 17 refs

Key Words: Shells, Elastic plastic properties, Time-dependent excitation

A numerical analysis of the elasto/visco-plastic dynamic response of the axisymmetrical shells to the time-varying load is made by the use of the elasto/visco-plastic overlay model which is able to express the Bauschinger effect and the strain rate dependency.

PIPES AND TUBES

(Also see Nos. 26, 95, 96, 208)

81-127
OTEC Cold Water Pipe Design for Problems Caused by Vortex-Excited Oscillations
O.M. Griffin
Naval Res. Lab., Washington, D.C., Rept. No. NRL-MR-4157, AD-E000 413, 149 pp (Mar 14, 1980) AD-A084 555/2

Key Words: Pipes (tubes), Fluid-induced excitation, Vortex-induced vibration

A survey of recent results pertaining to the vortex-excited oscillations of structures in general and to consider the application of these findings to the design of the OTEC cold water pipe is reported. Practical design calculations are given as examples throughout the various sections of the report. This report is limited in scope to the problems of vortex shedding from bluff, flexible structures in steady currents and the resulting vortex-excited oscillations.

81-128

Transmission of Sound Through Pipe Walls in the Presence of Flow

C.I. Holmer and F.J. Heymann

Noise Control Tech., Div. of Underwater Systems, Inc., Silver Spring, MD 20910, J. Sound Vib., 70 (2), pp 275-301 (May 22, 1980) 11 figs, 4 tables, 26 refs

Key Words: Pipes (tubes), Sound transmission

The transmission of sound through pipe walls was studied experimentally under no-flow conditions as well as with steady air flow velocities up to 120 m/s. The test specimens were commercial pipe and tube of diameter ranging from 0·07 to 0·3 m, and thickness-to-diameter ratios from 0·012 to 0·2. The technique involved two reverberant rooms, one traversed by the test pipe to measure externally radiated sound, and one in which the test pipe terminated to measure internally propagated sound. Vibration of the pipe wall was also monitored to determine radiation efficiency.

81-129

Vibration of Tubes in a Once Through Steam Generator During Steady State and Transient Power Operation

J.C. Simonis and L.H. Bohn

Southwest Res. Inst., San Antonio, TX, Flow-Induced Vibration of Power Plant Components. The Pressure Vessels and Piping Conf., PVP No. 41, Aug 12-15, 1980, San Francisco, CA, M.K. Au Yang, ed., ASME: 1980, pp 109-123, 15 figs, 2 refs

Key Words: Tubes, Boilers, Vibration measurement, Fluid-induced excitation

The vibratory response of four tubes in the B loop of the once-through steam generator was measured at a nuclear power station during steady-state and transient plant operation. The responses of the tubes were measured by biaxial accelerometers installed in the upper span of three tubes adjacent to a missing lane of tubes (open lane) and a biaxial accelerometer installed in one tube lane towards the interior of the tube bundle (off-lane).

81-130

Fluidelastic Vibration of Tube Arrays Excited by Nonuniform Cross Flow

H.J. Connors

Westinghouse R & D Ctr., Pittsburgh, PA, Flow-Induced Vibration of Power Plant Components. The Pressure Vessels and Piping Conf., PVP No. 41, Aug 12-15, 1980, San Francisco, CA, M.K. Au-Yang, ed., ASME: 1980, pp 93-107, 13 figs, 4 refs

Key Words: Tubes, Heat exchangers, Fluid induced excitation

Flow fields with highly nonuniform velocity distributions exist in many types of tubular heat exchangers. Nonuniform flow in the transverse direction created by inlet nozzle impingement plates is investigated. The impingement plate causes a high velocity skimming flow between the tube bundle and shell. Wind tunnel experiments were conducted using model tube arrays subjected to idealized skimming flow to identify and characterize the mechanism that has caused tube damage in heat exchangers.

81-131

Turbulence as Excitation Source in Staggered Tube Bundle Heat Exchangers

Y.N. Chen

Sulzer Brothers Limited, Winterthur, Switzerland, Flow-Induced Vibration of Power Plant Components. The Pressure Vessels and Piping Conf., PVP No. 41, Aug 12-15, 1980, San Francisco, CA, M.K. Au-Yang, ed., ASME: 1980, pp 45-63, 11 figs, 3 refs

Key Words: Heat exchangers, Tubes, Fluid-induced excitation, Turbulence, Vortex shedding

The role of turbulence as an excitation source in staggered tube bundles is investigated on models with various spacing ratios. It is found that turbulence plays an important role only in narrowly spaced tube bundles in which jet instability, jet switch, or wake swing without vortex shedding is a main excitation source.

81-132

The Effects of Artificially Induced Up-Stream Turbulence on the Liquid Cross-Flow Induced Vibration of Tube Bundles

D.J. Gorman

Dept. of Mech. Engrg., Univ. of Ottawa, Ottawa, Canada, Flow-Induced Vibration of Power Plant Components. The Pressure Vessels and Piping Conf., PVP No. 41, Aug 12-15, 1980, San Francisco, CA, M.K. Au-Yang, ed., ASME: 1980, pp 33-43, 5 figs, 1 table, 5 refs

Key Words: Heat exchangers, Tubes, Vortex shedding, Fluid-induced excitation

Vortex shedding can be a serious cause of tube bundle vibration at the inlet and second row tubes for bundles subjected to liquid cross-flow. Relatively large vibration amplitudes were measured for these inlet region tubes for a number of test bundles. An extensive series of tests were conducted during which the effect on this vibration of up-stream screens and grids was explored. Bundles which normally had inlet vortex resonances were utilized for the tests.

81-133

A Comprehensive Approach to Avoid Vibration and Fretting in Shell-and-Tube Heat Exchangers

M.J. Pettigrew and P.L. Ko

Atomic Energy of Canada Ltd., Chalk River Nuclear Labs., Chalk River, Ontario, Canada, Flow-Induced Vibration of Power Plant Components. The Pressure Vessels and Piping Conf., PVP No. 41, Aug 12-15, 1980, San Francisco, CA, M.K. Au-Yang, ed., ASME: 1980, pp 1-18, 14 figs, 1 table, 15 refs

Key Words: Tubes, Heat exchangers, Wear, Fluid-induced excitation

A comprehensive approach developed to avoid vibration and fretting-wear problems in shell-and-tube heat exchangers is outlined. The approach consists of avoiding large vibration amplitudes due to excitation mechanisms such as fluid-elastic instability and periodic wake shedding resonance while making sure that low amplitude vibrations due to other sources do not cause excessive tube damage. Design data on fluidelastic instability and periodic wake shedding in liquid flow are given in the paper. Fretting-wear predictions are outlined by an example.

81-134

Vibration Testing of a Straight Tube Type Steam Generator for FBR

K. Kobatake, M. Suzuki, A. Koishikawa, and T. Hashimoto

Engrg. Dept., Nuclear Systems Div., Kawasaki Heavy Industries, Ltd., Tokyo, Japan, Flow-Induced Vibration of Power Plant Components. The Pressure Vessels and Piping Conf., PVP No. 41, Aug 12-15, 1980, San Francisco, CA, M.K. Au-Yang, ed., ASME: 1980, pp 19-31, 20 figs, 5 tables, 14 refs

Key Words: Tubes, Boilers, Vibration tests, Fluid-induced excitation

Experimental and theoretical results for tubes vibrating in air and stationary water are presented. The information was obtained for design of FBR steam generator. Effects on frequency, damping, and dynamic response of varying the span of the tube supports, as well as introducing tension in the tubes, are described.

DUCTS

(Also see No. 170)

81-135

The Acoustic Output Produced by a Steady Airflow Through a Corrugated Duct

A.M. Petrie and I.D. Huntley

Paisley College of Tech., Paisley PA1 2BE, Scotland, J. Sound Vib., 70 (1), pp 1-9 (May 8, 1980) 7 figs, 12 refs

Key Words: Ducts, Corrugated structures, Noise generation

The noise produced by a steady flow of air through a duct which is internally corrugated is investigated. Experiments are described and several methods of attenuation are discussed.

81-136

Rigorous Solutions for Sound Radiation from Circular Ducts with Hyperbolic Horns or Infinite Plane Baffle

Y.C. Cho

NASA Lewis Res. Ctr., Cleveland, OH 44135, J. Sound Vib., 69 (3), pp 405-425 (Apr 8, 1980) 15 figs, 2 tables, 20 refs

Key Words: Ducts, Elastic waves, Sound propagation

A rigorous treatment is presented of sound radiation from circular ducts with either a hyperbolic horn or an infinite plane baffle. In the analysis hyperboloidal wave functions are used, which are defined here, for the first time, as a class of eigensolutions of the wave equation for oblate spheroidal co-ordinates. The numerical results include the complex conversion (or reflection) coefficients and the radiation directivity for various incident wave modes, spinning modes as well as axisymmetric modes.

ELECTRIC COMPONENTS

MOTORS

(See No. 161)

DYNAMIC ENVIRONMENT

ACOUSTIC EXCITATION

(Also see Nos. 13, 14, 19, 40, 49, 50, 51, 105, 169)

81-137

Time History Analysis of Multi-Impact Noise

K. Atkinson and P. Lamb

Commonwealth Scientific and Industrial Res. Organization, Div. of Textile Industry, P.O. Box 21, Belmont, Victoria 3216, Australia, Noise Control Engr., 15 (1), pp 6-10 (July/Aug 1980) 9 figs, 7 refs

Key Words: Noise generation, Time-dependent excitation, Noise source identification, Spectrum analyzers

Time history analysis is an important tool in noise control. It can be used to identify and rank the major impacts of a multi-impact noise source when they are not audibly resolved. It is shown how this technique may now be easily implemented on modern digital spectrum analyzers.

81-138

A Powerful Asymptotic Solution for Sound Propagation Above an Impedance Boundary

S.I. Thomasson

Dept. of Bldg. Acoustics, Lund Inst. of Tech., S-220 07 Lund, Sweden, Acustica, 45 (2), pp 122-125 (June 1980) 6 refs

Key Words: Sound waves, Point source excitation

A solution is developed for the problem of sound radiation from a point source above an impedance plane. It is valid for any location of the source and the receiver and for an arbitrary impedance of the plane. The solution is expressed in terms of the complementary error function and gives an accuracy that is comparatively difficult to obtain by numerical integration of the exact solution.

81-139

Second Order Low-Frequency Scattering by the Soft Ellipsoid

G. Dassios

Dept. of Mathematics, National Tech. Univ. of Athens, Athens, Greece, SIAM J. Appl. Math., 38 (3), pp 373-381 (June 1980) 14 refs

Key Words: Acoustic scattering

Low-frequency scattering of a plane wave by a triaxial ellipsoid for the case where the field vanishes on its surface is considered.

81-140

The Dissipation of Sound at an Edge

M.S. Howe

Bolt Beranek and Newman, Inc., 50 Moulton St., Cambridge, MA 02138, J. Sound Vib., 70 (3), pp 407-411 (June 8, 1980) 2 figs, 17 refs

Key Words: Acoustic scattering, Pipes (tubes)

A general formula is established for the rate at which acoustic energy is dissipated at the sharp edges of a rigid boundary by the generation of vorticity in the presence of a low, subsonic mean flow of uniform mean density.

81-141

Sound Absorption Caused by Vorticity Shedding, Demonstrated with a Jet Flow

D.W. Bechert

Deutsche Forschungs- und Versuchsanstalt für Luft- und Raumfahrt, Müller-Breslau-Strasse 8, 1000 Berlin (West) 12, Germany, J. Sound Vib., 70 (3), pp 389-405 (June 8, 1980) 10 figs, 49 refs

Key Words: Acoustic absorption, Vortex shedding, Multipole analysis

A low frequency sound wave can be absorbed significantly when transmitted through a nozzle and a jet flow. The basic underlying physical phenomenon is that acoustic energy is converted into energy of fluctuating vorticity, which is shed from the nozzle edge. Different theories have become available which already yield an excellent quantitative description of this effect. These theories are discussed, and a derivation of the simplest of them, a multipole analysis, is presented.

81-142

A Finite Element Analysis of Parallel-Coupled Acoustic Systems Using Subsystems

D.F. Ross

Res. and Advanced Engrg. Lab., Arvin Industries, Inc., West Lafayette, IN 47906, J. Sound Vib., 69 (4), pp 509-518 (Apr 22, 1980) 8 figs, 16 refs

Key Words: Acoustic emission, Coupled systems, Engine mufflers, Finite element technique

A Lagrangian energy expression is presented that is suitable for finite element analysis of parallel-coupled acoustic systems, as a series of subsystems. The technique has been applied to automotive muffler configurations and has been verified experimentally.

81-143

A Comparison Between an Existing Propeller Noise Theory and Wind Tunnel Data

J.H. Dittmar

NASA Lewis Res. Ctr., Cleveland, OH, Rept. No. NASA-TM-81519, E-462, 41 pp (May 1980) N80-25101

Key Words: Propeller noise, Noise prediction, Noise measurement, Wind tunnel tests

The noise of three supersonic helical tip speed propellers was compared with the noise predicted by an existing noise theory. Comparisons of the peak blade passage tones showed fairly good agreement between theory and experiment at the lowest helical tip Mach numbers tested, while at higher numbers, the theory predicted higher noise levels than measured.

81-144

Statistical and Energy-Averaged Metrics for Community Noise Assessments

A.B. Broderson

Watkins and Associates, Inc., J. Environ. Sci., 23 (4), pp 24-30 (July/Aug 1980) 4 figs, 10 refs

Key Words: Urban noise, Noise measurement, Measurement techniques, Statistical analysis, Statistical energy methods

A review of both the statistical and energy-averaged noise metrics is presented demonstrating the effectiveness of both, and illustrating how one can translate from one to the other. An approach to monitoring which uses the advantages of both metrics, but at relatively low cost, is also shown.

81-145

Sound Radiation from a Surface of Porous Material

S. Oie and R. Takeuchi

The Inst. of Scientific and Industrial Res., Osaka Univ., Yamadakami, Suita, Osaka 565, Japan, Acustica, 45 (2), pp 87-95 (June 1980) 11 figs, 7 refs

Key Words: Porous materials, Vibrating structures, Elastic waves, Acoustic absorption

The sound field radiated from a surface of porous material vibrating uniformly is theoretically analyzed. The efficiency coefficients of radiation and the sound absorption coefficients of the porous material in a few examples of a one-dimensional problem are numerically calculated and their frequency responses are presented graphically.

81-146

Materials for Noise and Vibration Control

W.E. Purcell, Ed.

S/V, Sound Vib., pp 8-32 (July 1980) 38 figs, 2 tables

Key Words: Noise reduction, Vibration control, Absorbers (materials), Acoustic absorption, Noise barriers, Vibration damping, Vibration isolation

The mechanisms of sound absorption, sound transmission loss by sound barriers, vibration damping, and vibration isolation are described.

81-147

Plastic Strip and Sheet Barriers

J.J. Hohman

Fabricated Polymers Div., The BF Goodrich Co., Akron, OH, Plant Engr., 34 (16), pp 71-73 (Aug 7, 1980) 2 figs, 3 tables

Key Words: Noise reduction, Noise barriers, Plastics

The benefits of plastic barriers for noise control as well as for containing of conditioned air and welding radiation are described.

81-148

Resonating Fields Inside Elastic Scattering Objects

L. Flax, P.K. Raju, J. George, and H. Überall

Naval Res. Lab., Washington, D.C. 20375, J. Acoust. Soc. Amer., 68 (3), pp 973-979 (Sept 1980) 12 figs, 14 refs

Key Words: Acoustic scattering, Cylinders, Underwater sound, Underwater structures

The resonance theory of acoustic scattering from elastic objects predicts the field exterior to the scattering object to consist of resonance terms, superimposed on a nonresonant background which corresponds to the scattering amplitude for an impenetrable object. In contrast, the interior field is predicted to consist of resonant amplitudes only, so that a substantial amount of penetration of the incident field into the scatterer occurs only at and near the resonance frequencies of the body. We have made quantitative numerical studies of the interior fields in glass cylinders imbedded in water, and subject to incident acoustic fields from far distant or nearby line sources. The results are compared to, and agree with, experimentally measured fields inside glass cylinders as visualized by the method of optic-elastic birefringence. The study of resonances in the separate partial wave amplitudes will additionally lead to the interpretation of resonances in terms of circumferential waves, whose dispersion curves are obtained here as a function of the Poisson ratio of the cylinder.

81-149

Highway Noise Abatement

G.S. Anderson, C.W. Menge, F.L. Hall, H.S. Knauer, and R.E. Armstrong

Transportation Res. Board, Washington, D.C., Rept. No. TRB/TRR-740, ISBN-0-309-02998-8, 38 pp (1980)

PB80-190622

Key Words: Noise reduction, Transportation noise, Traffic noise, Noise barriers

The six papers in this report deal with the following areas: barrier cost reduction program; attitudes toward noise barriers before and after construction; sound-absorption treatments for highway noise barriers; noise barriers adjacent to I-95 in Philadelphia; effectiveness of noise barriers along the Capital beltway in northern Virginia; and systematic method for prioritizing barrier retrofit projects for highways.

81-150

Highway Noise Criteria Study: Traffic Noise Data Base

D.R. Flynn, C.R. Voorhees, and S.L. Yaniv

National Engrg. Lab., National Bureau of Standards, Washington, D.C., Rept. No. NBS-TN-1113-1, 385 pp (Apr 1980)

PB80-179229

Key Words: Traffic noise, Human response, Data presentation

A traffic noise data base that was obtained as part of a large research program developed to identify and quantify the important physical parameters which affect human response to time-varying traffic noise is documented and various procedures for rating such noise so as to enable reliable predictions of subjective response to the noise are investigated.

81-151

Some Aspects of the Surface Scattering of Underwater Sound

C. Gazanhes and J. Leandre

Laboratoire de Mecanique et d'Acoustique, Centre National de la Recherche Scientifique, 13274 Marseille Cedex 2, France, J. Sound Vib., 70 (1), pp 11-27 (May 8, 1980) 14 figs, 3 tables, 9 refs

Key Words: Underwater sound, Acoustic scattering

The mechanism of a sound wave reflection by the sea surface in the general context of the theory of time-variant communication channels theory is studied. It is shown that the surface scattering can be represented by a constant filter in parallel with a random filter. An experimental study conducted with a reduced scale model in an acoustic tank confirms the theoretical results.

SHOCK EXCITATION

(Also see Nos. 16, 29, 45, 46, 60, 180, 216)

81-152

Localized Impact Problems of Composite Laminates

N. Takeda and R.L. Sierakowski

Dept. of Engrg. Sciences, Univ. of Florida, Gainesville, FL, Shock Vib. Dig., 12 (8), pp 3-10 (Aug 1980) 1 fig, 44 refs

Key Words: Layered materials, Composite materials, Impact response (mechanical)

This article summarizes work on locally impacted composite material problems. Topics included are: localized damage experiments of filament reinforced composite materials, the solution of wave propagation problems based on continuum mechanics models, and Hertzian contact approaches to impact problems.

81-153

On Reliability-Based Structural Optimization for Earthquakes

J.W. Davidson, L.P. Felton, and G.C. Hart

Mechanics and Structures Dept., School of Engrg. and Applied Science, Univ. of California, Los Angeles, CA, Computers Struc., 12 (1), pp 99-105 (July 1980) 5 figs, 3 tables, 12 refs

Key Words: Optimum design, Seismic design, Earthquake response

A formulation is presented for the minimum-weight design of a structure subjected to an earthquake ground motion and constrained by a specified upper bound on overall probability of failure. The formulation includes a probabilistic representation of earthquake response spectrum shape and structural stiffness characteristics.

81-154

Critical Excitations for Linear and Nonlinear Structural Systems

A.J. Philippacopoulos

Ph.D. Thesis, Polytechnic Inst. of New York, 74 pp (1980)

UM 8019409

Key Words: Seismic excitation, Ground motion, Critical response spectra

A new type of seismic assessment of structures is described. The basis for this assessment lies in the concept of the "critical excitation". The latter is a seismic excitation which is generated by combining a properly selected set of recorded ground motions together with a maximization procedure. It is a site as well as system dependent excitation. Both linear and nonlinear structures were considered.

81-155

A Review of Human Tolerance to Side Impact

R.F. Neathery

Oklahoma State Univ., Stillwater, OK, Rept. No. DOT-HS-805 296, 19 pp (Sept 1979)

PB80-182983

Key Words: Collision research (automotive), Human tolerance, Standards and codes

Recent studies on the response and tolerance of human cadavers to side impact are reviewed. Attempts to statistically model these data in order to predict injury from side impact in motor vehicle crashes are detailed.

81-156

Airblast Attenuation Experiments for the M-X Trench

D.T. Hove and J.E. Craig

Science Applications, Inc., El Segundo, CA, Rept. No. SAI-79-546-LA, 150 pp (Dec 31, 1978)

AD-A085 725/0

Key Words: Shock tube tests, Air blast, Shock wave attenuation

A series of experiments were performed in the NASA Ames Electric Arc Shock Tube to investigate the propagation of strong shock waves in tubes with transverse ribs. The experiments were designed to measure shock attenuation, end wall reflected pressures, wall drag and flowfield structure to provide a basis for development of computer models for analysis of blast wave propagation in the M-X trench.

81-157

Airblast Experiments for the M-X Spur

J.E. Craig

Science Applications Inc., El Segundo, CA, Rept. No. SA1-79-569-LA, DNA-4721F, AD-E300 790, 49 pp (Dec 31, 1978)

AD-A085 580/9

Key Words: Shock tube tests, Air blast, Shock wave propagation

A series of experiments was performed in the NASA Ames Electric Arc Shock Tube to investigate the propagation of strong waves in a model of the M-X Spur. The experiments were designed to measure incident and reflected shock pressures to provide a basis for the development of computer models for analysis of blast wave propagation in the M-X Spur.

VIBRATION EXCITATION

(Also see No. 89)

81-158

Two Dimensional Stability Analysis of Two Coupled Conductors with One in the Wake of the Other

Y.T. Tsui and C.C. Tsui

Institut de Recherche de l'Hydro-Quebec, Varennes, Quebec, Canada, J. Sound Vib., 69 (3), pp 361-394 (Apr 8, 1980) 2 figs, 4 tables, 13 refs

Key Words: Flutter, Fluid-induced excitation

Two problems in wake-induced flutter; namely, flutter asymmetry and frequency coalescence, were clarified by using the Routh-Hurwitz stability criteria to study the flutter of the leeward conductor in the wake of the fixed windward conductor within the framework of quasi-steady aerodynamic theory. The two dimensional stability of two coupled conductors with and without damping is studied.

81-159

On Combinations of Random Loads

D.P. Gaver and P.A. Jacobs

Naval Postgraduate School, Monterey, CA, Rept. No. NPS55-80-006, 51 pp (Jan 1980)

AD-A085 489/3

Key Words: Random loads, Probability theory

Certain simple but somewhat realistic probabilistic load models are given and the resulting probabilistic model of the total stress on the structure caused by the loads is considered.

81-160

Interdependence of the Spectral Densities of Multiple Responses

S. Mahalingam, D.B. Macvean, and J.D. Robson

Dept. of Mech. Engrg., Univ. of Glasgow, Glasgow G12 8QQ, Scotland, J. Sound Vib., 69 (3), pp 461-476 (Apr 8, 1980)

Key Words: Spectral energy distribution techniques, Random excitation, Linear systems

The spectral densities (direct and cross) of the multiple response records of a linear system, such as a structure, subjected to multiple random excitation are analyzed.

MECHANICAL PROPERTIES

DAMPING

(Also see Nos. 75, 146, 213, 214)

81-161

Damping and the Step Motor

V. Coughlin, Ed.

Design Engineering, pp 55-57 (Sept 1980) 8 figs

Key Words: Motors, Coulomb friction, Vibration damping

Several mechanical and electronic damping methods for stabilizing step motors are briefly discussed.

FATIGUE

(Also see Nos. 205, 211)

81-162

Damage Accumulation and Fracture Criterions for Cyclic Multistage Loads (Schadensakkumulations- und Bruchkriterien für zyklische Mehrstufenbeanspruchungen)

J. Wölfel

VEB Komplette Chemieanlagen (KCA), Dresden, Maschinenbautechnik, 29 (1), pp 38-41 (1980) 5 figs, 7 refs

(In German)

Key Words: Fatigue (materials), Fracture properties

A working hypothesis with a general method and a tested setup for computation of the damages of materials owing to any cyclic stress is presented. Examples of single-stage stresses and multistage stresses, order influences, etc. explain the computation method.

81-163

Minicomputer Relates Vibration and Fatigue

T.R. Comstock, T. Dilger, and T. Bernard

Structural Dynamics Res. Corp., Milford, OH, Reliability, Stress Analysis and Failure Prevention Methods in Mechanical Design, Intl. Conf., Aug 18-21, 1980, San Francisco, CA, W.D. Milestone, ed., ASME: 1980, pp 263-268, 15 figs, 4 refs

Key Words: Fatigue life, Graphic methods, Computer-aided techniques

An approach is presented which uses a minicomputer based system for data acquisition and analysis with graphic displays as it relates to fatigue life estimation and design. Procedures are developed for identifying and eliminating damaging events due to either overall duty cycle, forced vibration or structural dynamic characteristics. Two case histories are discussed to illustrate the overall approach.

81-164

Combined Fatigue Stress Concentration Factor Determination

G.M. Kurajian and T.Y. Na

Univ. of Michigan, Dearborn, MI, Reliability, Stress Analysis and Failure Prevention Methods in Mechanical Design, Intl. Conf., Aug 18-21, 1980, San Francisco, CA, W.D. Milestone, ed., ASME: 1980, pp 285-291, 4 figs, 4 tables, 11 refs

Key Words: Fatigue life, Machinery components, Design techniques

A view of the state of the art embracing the spectrum of methods employed by different designers to account for all stress concentration effects in calculations for use in the design of machine elements and components subjected to combined/fatigue loadings is presented.

81-165

A Methodology for the Evaluation of Fatigue Damage in Structures Exposed to Random Excitation

R.A. Kenny and S. Chandra

Combustion Engineering, Inc., Windsor, CT, Reliability, Stress Analysis and Failure Prevention Methods in Mechanical Design, Intl. Conf., Aug 18-21, 1980, San Francisco, CA, W.D. Milestone, ed., ASME: 1980, pp 293-295, 2 figs, 1 table, 6 refs

Key Words: Fatigue life, Random excitation

A method is offered for the determination of how many and which modes contribute significantly to total response and how fatigue damage may be calculated for that response.

ELASTICITY AND PLASTICITY

81-166

Dynamic Behavior of Structures Composed of Strain and Workhardening Visco-Plastic Materials

A.R.S. Ponter

Dept. of Engrg., Leicester Univ., Leicester, UK, Intl. J. Solids Struc., 16 (9), pp 793-806 (1980) 10 figs, 11 refs

Key Words: Viscoplastic media, Dynamic structural analysis

A dynamic convergence theorem is proven for a class of visco-plastic constitutive equations involving internal state variables, which provides an extension of a result due to Martin.

81-167
Wave Propagation in Anisotropic Non-Homogeneous Thermoviscoelastic Media
D. Turhan
Dept. of Engrg. Sciences, Middle East Technical Univ., Ankara, Turkey, J. Sound Vib., 69 (4), pp 569-582 (Apr 22, 1980) 1 fig, 21 refs

Key Words: Thermoviscoelasticity theory, Wave propagation

Propagation of waves in linear anisotropic non-homogeneous thermoviscoelastic media is investigated by employing the basic ideas of the theory of singular surfaces and of ray theory.

EXPERIMENTATION

MEASUREMENT AND ANALYSIS

(Also see No. 56)

81-168
The Direct Measurement of Acoustic Energy in Transient Sound Fields
R.J. Alfredson
Dept. of Mech. Engrg., Monash Univ., Clayton, Victoria 3168, Australia, J. Sound Vib., 70 (2), pp 181-186 (May 22, 1980) 3 figs, 17 refs

Key Words: Acoustic measuring instruments, Digital techniques, Graphic methods

A device based on two closely spaced microphones has been developed for measuring acoustic energy in transient sound fields. A graph of the acoustic energy, as a function of time, is obtained at any nominated position and direction. All processing of the signals is carried out digitally.

81-169
Study of an Experimental Probe for the Measurement of the Acoustic Pressure Inside An Airflow
H. Huguenin
Office National d'Etudes et de Recherches Aerospatiales, Paris, France, Rept. No. ONERA-NT-1979-5, ESA-TT-633, 63 pp (1979)

Key Words: Noise measurement, Measurement techniques

The turbulence generated by the presence of a microphone placed to study the origin of noise of an aircraft in motion, and the effect it has upon the measurements of acoustic pressure within the fluids in motion, are discussed. An acoustic probe, designed to reduce the influence of the instrument during such measurements is described.

81-170
An Impulse Test Technique with Application to Acoustic Measurements
M. Salikuddin, P.D. Dean, H.E. Plumblee, Jr. and K.K. Ahuja
Lockheed-Georgia Co., Marietta, GA 30063, J. Sound Vib., 70 (4), pp 487-501 (June 22, 1980) 16 figs, 12 refs

Key Words: Measurement techniques, Ducts, Acoustic linings, Acoustic absorption

A method is described for measuring the acoustic properties of an absorbent material and a duct/nozzle system (with or without airflow) in which a high voltage spark discharge is used as an impulse source of sound. The cross-spectra of the incident, reflected and transmitted acoustic pressure transients are analyzed by way of an FFT digital processor in the form of complex transfer functions. The impulse method has been justified by comparisons that show excellent agreement with data obtained from existing methods.

81-171
Visual Characteristics of Inhomogeneous Acoustic Waves
J.A. Clark
Acousto-Optics Lab., Catholic Univ. of America, Washington, D.C. 20064, J. Sound Vib., 70 (2), pp 267-273 (May 22, 1980) 2 figs, 14 refs

Key Words: Elastic waves, Wave propagation, Holographic techniques, Interferometers

Experimentally obtained visualizations of propagating inhomogeneous acoustic waves driven by zero-order antisymmetric Lamb waves (flexural waves) in water are presented. The inhomogeneous waves are visualized by optical holo-

graphic interferometry. A series of photographs show the evolution in time of instantaneous acoustic pressure distributions associated with propagating inhomogeneous waves.

81-172

A Holographic Technique with Computer Aided Analysis for the Measurement of Wear

D. Groves, M.J. Lalor, N. Cohen, and J.T. Atkinson

Dept. of Mechanical, Marine and Production Engrg., Liverpool Polytechnic, Byrom St., Liverpool L3 3AF, UK, J. Phys. E. (Sci. Instr.), 13, pp 741-746 (July 1980) 14 figs, 3 refs

Key Words: Wear, Holographic techniques, Measurement techniques, Computer aided techniques

A technique is described which utilizes the three dimensional information contained in photographs of contour fringed holographic images of surfaces to determine the volume change of a body due, for example, to wear. The contour fringes are produced on the holographic image of a surface by dual index holographic contouring.

81-173

Piezoelectric Vibration Detector for Sensing a Nearby Intruder

J.T. Redfern

Dept. of the Navy, Washington, D.C., U.S. PATENT 4 194 194, 4 pp (Mar 1980)

Key Words: Vibration detectors, Piezoelectric transducers

An intrusion sensor using thin film piezoelectric transducers to sense nearby mechanical vibrations is described. The hose-like sheath contains a pair of insulating strips which carry conductive leaves on their outer surfaces.

81-174

A Fiber-Optic Laser-Doppler Probe for Vibration Analysis of Rotating Machines

R.A. Cookson and P. Bandyopadhyay

Applied Mechanics, School of Mech. Engrg., Cranfield Inst. of Tech., Cranfield, Bedford, UK, J. Lubric. Tech., Trans. ASME, 102 (3), pp 607-612 (July 1980) 2 figs, 5 tables, 7 refs

Key Words: Rotating structures, Vibration measurement, Vibration probes, Amplitude measurement, Frequency measurement

The problem of obtaining vibratory information from remote, rotating, components within a machine has been overcome by means of a laser-Doppler fiber-optic probe. Laser light is transmitted down the fiber-optic and scattered light is returned for analysis in the same way.

81-175

Interface Problems of Measurement

G.M. Hieber

Hieber Engineering, Watchung, NJ, Hydraulics & Pneumatics, 33 (8), pp 66-70, 76 (Aug 1980) 7 figs

Key Words: Measurement techniques, Vibration measurement

The importance of proper installation of sensors for the measurement of motion (displacement, acceleration and velocity), force, torque and flow is discussed, taking into consideration the interaction, across and through variables, and natural frequency of the sensor.

81-176

Rotating Machinery Rolling Element Bearing Performance Monitoring Using the Fiber Optic Method

G.J. Philips

David W. Taylor Naval Ship R & D Ctr., Annapolis, MD, Reliability, Stress Analysis and Failure Prevention Methods in Mechanical Design, Intl. Conf., Aug 18-21, 1980, San Francisco, CA, W.D. Milestone, ed., ASME: 1980, pp 37-43, 15 figs, 14 refs

Key Words: Vibration measurement, Measurement techniques, Vibration probes, Fiberscopes, Bearings

Fiber optic proximity probes are mounted inside a bearing housing to directly measure the vibrations on the outer race of the bearing. This method is compared to the traditional methods which utilize externally mounted sensors.

81-177

Horizontal Contact Resonances of Vibration Pickup with Rectangular Bases on Soil Surfaces

S. Omata and S. Morita

College of Engrg., Nihon Univ., Tokusada, Koriyama, Fukushimaken 963, Japan, J. Acoust. Soc. Amer., 68 (2), pp 393-403 (Aug 1980) 15 figs, 10 refs

Key Words: Measuring instruments, Vibration measurement, Ground vibration

The characteristics of the horizontal contact resonances of the rectangular vibration pickup with various base shapes are indicated and expressions for a coupled motion of the pickup are derived. It is suggested that the horizontal resonance and the response of the coupling system of the rectangular vibration pickup are significantly affected by the height of the center of gravity, the base area, and the base shape.

81-178

Sensible Display of Power Spectral Density Information

W.D. Everett

Pacific Missile Test Ctr., J. Environ. Sci., 23 (4), pp 21-24 (July/Aug 1980) 4 figs, 1 ref

Key Words: Data presentation, Power spectra, Random vibration

It is increasingly popular to display random vibration power spectral density data in logarithmic formats and the resultant distorted display is misleading in describing the vibration spectra. Some of the errors that the logarithmic formatting promotes are identified; a rationale for determining a linear format is proposed; and a request is made that random vibration analysis community adopt some uniform format, incorporating linear scales, for PSD presentation.

81-179

A Frequency Domain Analysis of the Linear Discrete Kalman Filter

W.J. Costello

Naval Postgraduate School, Monterey, CA, Master's thesis, 100 pp (Mar 1980)
AD-A085 058/6

Key Words: Filters, Frequency domain method

The linear discrete Kalman filter is analyzed using a frequency domain approach. Process and measurement noise covariances are shown to be critical design parameters which, together with the assumed prior state and coverience estimates, completely determine the gain schedule of the linear Kalman filter. Several relevant design techniques are illustrated and discussed.

DYNAMIC TESTS

(Also see Nos. 24, 25, 31, 215)

81-180

Simulation of Dynamic Environments for Design Verification

M.S. Agbabian

Agbabian Associates, 250 N. Nash St., El Segundo, CA, 90245, Nucl. Engr. Des., 59 (1), pp 127-141 (July 1980) 15 figs, 13 refs

Key Words: Dynamic tests, Testing techniques, Earthquake response, Nuclear reactors, Reviews

Surveys on verification techniques are updated in this report to include recent applications in nuclear facilities that use transient methods for dynamic excitation. Brief discussions of the theoretical considerations underlying this testing approach, as well as requirements for correlation of experimentally and analytically derived data are covered.

81-181

Development and Evaluation of a Belt Restraint System for Small Cars Using Force Limiting

Calspan Corp., Buffalo, NY, Rept. No. CALSPAN-6174-V-3, DOT-HS-805 303, 518 pp (Apr 1979)
PB80-187347

Key Words: Safety restraint systems, Seat belts, Dynamic tests

Development and evaluation of a force limited belt restraint system for small cars has been completed. The belt restraint system with passive capability was developed through the use of three dimensional computer simulations and sled tests.

81-182

A Test Facility for the Measurement of Heavy Vehicle Suspension Parameters

C.B. Winkler and M. Hagan

Highway Safety Res. Inst., Univ. of Michigan, SAE Paper No. 800906, 32 pp, 16 figs, 1 table, 6 refs

Key Words: Test facilities, Suspension systems (vehicles)

A new facility for the measurement of the compliance, kinematic and coulomb friction properties of heavy vehicle suspensions is described. The facility may test single or tandem and front or rear suspensions. Test procedures for measurement of vertical and roll rates, kinematic and compliant steer effects are presented. Qualitative findings are discussed and example data is appended.

SCALING AND MODELING

81-183
Measurements of Nonlinear Wheelset Forces in Flange Contact Using Dynamically Scaled Models

L.M. Sweet, J.A. Sivak, and W.F. Putman
Dept. of Mech. and Aerospace Engrg., Princeton Univ., Princeton, NJ, Rept. No. MAE/TR-1406, DOT/RSPA/DPB-50-80/6, 112 pp (Mar 1980) PB80-190747

Key Words: Railroad cars, Interaction: rail-wheel, Test models, Scaling

New experimental methods are presented for the study of rail vehicle dynamics through the use of scaled models on tangent track, and the application of these techniques to the measurement of nonlinear wheelset force/displacement relations in steady-state.

DIAGNOSTICS

81-184
Identification of Cracks in Welded Joints of Complex Structures

T.G. Chondros and A.D. Dimarogonas
School of Engrg., Univ. of Patras, Patras, Greece, J. Sound Vib., 69 (4), pp 531-538 (Apr 22, 1980) 8 figs, 11 refs

Key Words: Crack detection, Failure analysis, Joints (junctions), Welded joints, Beams, Cantilever beams

The problem of the influence of a crack in a welded joint on the dynamic behavior of a structural member is discussed. Analytical and experimental investigations show the relation between the change in natural frequency of vibration of a cantilever beam and the crack depth that appears at the built-in edge which is clamped by a weld.

81-185
A New Method for the Determination of Ball Bearing Damage (Ein neues Verfahren zur Bestimmung von Wälzlagerschaden)

W. Berndt and J. Kolitsch
VDI Z., 122 (12), pp 487-490 (June 1980) 3 figs, 10 refs
(In German)

Key Words: Bearings, Ball bearings, Diagnostic techniques

A new method for the determination of bearing damage using a wire strain gauge was developed. It is based on the determination of local stresses in a stationary, as well as on a rotating portion of the bearing. The method is independent of bearing loads and does not have to be calibrated. It is applicable for bearings of any size and at any speed.

81-186
Analysis of Repetitive Mechanism Signatures

S. Braun and B. Seth
Faculty of Mech. Engrg., Technion-Israel Inst. of Tech., Haifa, Israel, J. Sound Vib., 70 (4), pp 513-526 (June 22, 1980) 12 figs, 2 tables, 8 refs

Key Words: Signal processing techniques, Signature analysis, Rotating structures

A new signal decomposition for repetitive signatures is introduced based on the concept of derived time series, produced by rearranging the original signal by using points one period apart. Time domain averaging is shown to be a special case of such rearrangement, and a second technique of variance analysis is presented.

81-187
Development and Analysis of Protection Systems Based on the Frequency Signals (Entwicklung und Analyse eines Schutzsystems auf der Basis von Frequenzsignalen)

G. Meyer

Fortschritt-Ber. VDI-Zt., Ser. 8, No. 32 (1980), 158 pp, 68 figs, Price: 85.00-DM. Avail: VDI Verlag GmbH, Postfach 1139, Düsseldorf 1, Germany. Summarized in VDI-Z. 122 (11), p 43 (June 1980)
(In German)

Key Words: Failure analysis, Signal processing techniques, Nuclear reactors

A new protection system for structures with a high potential of danger to man and the environment, such as nuclear facilities, is proposed. The development, construction, and testing of the protection system based on the frequency signals is described. A discussion of the most important characteristics of components, the interconnection of components, and the necessary frequency range for signal transmission is included.

MONITORING

81-188

Acoustic Emission Weld Monitor System. Data Acquisition and Investigation

R.A. Groenwald, T.A. Mathieson, and C.T. Kedzior
GARD Inc., Niles, IL, Rept. No. TARADCOM-TR-12468, 71 pp (Oct 1979)
AD-A085 518/9

Key Words: Acoustic emission, Monitoring techniques, Welded joints, Data processing

The standard weld inspection techniques of radiography and ultrasonics have intrinsic disadvantages. The new technology of acoustic emission has shown an applicability to weld inspection which could overcome such disadvantages. This program is directed at utilizing acoustic-emission as a weld monitoring technique on a specific Army welding application.

81-189

A Doppler Technique for Detecting and Locating Excessively Vibrating Blades in a Running Turbine

R.L. Leon
Franklin Res. Ctr., A Division of the Franklin Inst., Philadelphia, PA, Reliability, Stress Analysis and Failure Prevention Methods in Mechanical Design, Intl. Conf., Aug 18-21, 1980, San Francisco, CA, W.D. Milestone, ed., ASME: 1980, pp 59-66, 19 figs, 4 refs

Key Words: Rotor blades (turbomachinery), Monitoring techniques, Doppler effect

A method is presented for pinpointing those blades of a running turbine that might be vibrating excessively in resonance with either running speed, nozzle passing frequency, or one of their harmonics. Only one stationary sensor per stage is required, along with a once-per-rev phase reference signal. The method utilizes specific signal manipulations in both the time and frequency domains to uncover the telltale Doppler signature, which normally would be masked in the raw signal.

81-190

Nearest Neighbor-Time Series Analysis Classification of Faults in Rotating Machinery

W. Gersch, T. Brotherton, and S. Braun
Dept. of Information and Computer Sciences, Univ. of Hawaii, Honolulu, HI, Reliability, Stress Analysis and Failure Prevention Methods in Mechanical Design, Intl. Conf., Aug 18-21, 1980, San Francisco, CA, W.D. Milestone, ed., ASME: 1980, pp 51-58, 3 figs, 18 refs

Key Words: Rotating structures, Failure analysis, Monitoring techniques

A unified nearest neighbor-time series analysis approach to the problem of the classification of faults in rotating machinery is developed. Examples of the classification of acceleration, pressure and torque sensor data from stationary, locally stationary and covariance stationary time series with mean value time functions are considered. Estimates of the probability of misclassification are computed for each situation.

81-191

An Experimental Evaluation of Direct and Indirect Methods for Assessing Machinery Condition

G.D. Xistris and T.S. Sankar
Dept. of Mech. Engrg., Concordia Univ., Montreal, Canada, Reliability, Stress Analysis and Failure Prevention Methods in Mechanical Design, Intl. Conf., Aug 18-21, 1980, San Francisco, CA, W.D. Milestone, ed., ASME: 1980, pp 45-50, 6 figs, 15 refs

Key Words: Monitoring techniques, Machinery, Fatigue life, Probability theory, Stochastic processes

A comparative study of the direct and indirect methods of assessing industrial machinery condition is presented, supported by an experimental investigation on a small internal combustion engine. Both quantitative and qualitative correlations are discussed and a set of recommendations for future applications is proposed.

ANALYSIS AND DESIGN

ANALYTICAL METHODS

(Also see No. 142)

81-192

Approximate Analysis of Non-Linear Systems by Laplace Transform

S.B. Karmakar
Bell Labs., Whippany Rd., Whippany, NJ 07981, J. Sound Vib., 69 (4), pp 597-602 (Apr 22, 1980) 2 figs, 12 refs

Key Words: Laplace transformation, Nonlinear systems, Time domain method

The possibilities of extending the Laplace transform method to the domain of non-linear systems analysis is discussed. The equation representing a given non-linear system is first transformed from the time domain to a multidimensional frequency domain by introducing the concept of a generalized transfer function. Transformation from the multidimensional domain to a domain of a single dimension is obtained by the technique of association of variables. Time domain response is then found by inverse Laplace transformation.

81-193

Eigenvalues for Unstable Resonators with Slightly Misaligned Strip Mirrors

C. Santana and L.B. Felsen
Instituto de Pesquisas Espaciais, Sao Jose dos Campos, Brazil, Rept. No. INPE-1738-RPE/137-REV, 17 pp (May 1980)
N80-26140

Key Words: Resonators, Eigenvalue problems

Very small misalignments in unstable strip resonators may cause detachment of the low loss eigenmode at lower equivalent Fresnel number, N sub eq, and introduce different periodicities into the eigenvalue curve as a function of N sub eq. Using the resonance equation developed previously from waveguide mode theory, this behavior is explained in physical terms by coupling between mode fields with even and odd symmetry, which are uncoupled in the perfectly aligned configuration. A simplified explicit equation derived for the eigenvalues of the detached mode is found to predict correctly the periodicities of the eigenvalue oscillations.

81-194

An Integral Equation Approach for the Generation of Seismic Power Spectral Density Functions

C. Sundararajan and G.D. Gupta
EDS Nuclear, Inc., San Francisco, CA 94104, J. Pressure Vessel Tech., Trans. ASME, 102 (3), pp 264-270 (Aug 1980) 3 figs, 7 tables, 8 refs

Key Words: Seismic response spectra, Spectral energy distribution techniques, Integral equations

An integral equation approach is presented for the generation of seismic power spectral density functions from specified response spectra. The problem of generating the response spectrum consistent power spectral density function is formulated as an integral equation with an inequality constraint and the equation is solved by collocation technique. An example problem is solved and the convergence of the solution is studied.

81-195

Dynamic Reduction of Structural Models

C.A. Miller
Dept. of Civ. Engrg., City College of New York, New York, NY, ASCE J. Struc. Div., 106 (ST 10), pp 2097-2108 (Oct 1980) 6 figs, 4 refs

Key Words: Dynamic structural response, Reduction methods

The errors associated with the reduction of the structural static degrees of freedom before performing a dynamic analysis are considered. It is shown that the standard methods of performing the reduction can lead to significant errors especially for the member loads computed in a forced vibration problem. A modified reduction is developed which is shown to significantly reduce the errors.

MODELING TECHNIQUES

81-196
Modal Methods in Finite Element Fluid-Structure Eigenvalue Problems
W.J.T. Daniel
Dept. of Mech. Engrg., Univ. of Queensland, Brisbane, Australia, Intl. J. Numer. Methods Engr., 15 (8), pp 1161-1175 (Aug 1980) 1 fig, 5 tables, 17 refs

Key Words: Interaction: structure-fluid, Eigenvalue problems, Modal synthesis, Finite element technique

The technique of fixed-interface modal synthesis used to solve large structural eigenvalue problems is extended to fluid-structure eigenvalue problems with a view to efficient solution of problems involving localized modifications. Three cases are considered.

81-197
Bond Graphs - A Modelling Tool
B.A. White
School of Electrical Engineering, Univ. of Bath, UK, Trans. Inst. Meas. Control, 1 (3), pp 176-184 (Sept 1979) 13 figs, 3 tables, 19 refs

Key Words: Bond graph technique, Mathematical models

Basic concepts of the theory of bond graphs is presented as an aid to synthesizing and analyzing dynamic systems.

NONLINEAR ANALYSIS

81-198
Nonlinear Structural Dynamics Via Newton and Quasi-Newton Methods
M. Geradin, S. Idelsohn, and M. Hogge
Aerospace Lab. of the Univ. of Liege B-4000 Liege, Belgium, Nucl. Engr. Des., 58 (3), pp 339-348 (June 1980) 9 figs, 8 refs

Key Words: Nonlinear theories, Dynamic structural analysis

Comparison of Newton and quasi-Newton methods in nonlinear structural dynamics is attempted. After a review of the classical iterative methods, several quasi-Newton updates are presented and tested. Special attention is devoted to the solution of large sparse systems for which two original procedures are described: a substructure correction and a vectorial correction. Numerical examples are presented.

NUMERICAL METHODS

81-199
Numerical Operational Methods in Structural Dynamics
G.V. Narayanan
Ph.D. Thesis, Univ. of Minnesota, 298 pp (1980)
UM 8019552

Key Words: Dynamic structural analysis, Laplace transformation, Numerical analysis

A general and systematic discussion on the use and importance of the operational method of Laplace transform for determining the response of large linear dynamic systems governed by partial or ordinary differential equations of the second order with respect to time is presented. Various existing methods of numerical inversion of Laplace transform are reviewed and critically discussed in great detail.

STATISTICAL METHODS

81-200
Random Response of Identical, One-Dimensional Coupled Subsystems
P.W. Smith, Jr.
Bolt Beranek and Newman, Inc., 50 Moulton St., Cambridge, MA 02138, J. Sound Vib., 70 (3), pp 343-353 (June 8, 1980) 3 figs, 6 refs

Key Words: Coupled systems, Random response, Statistical energy analysis

A precise statistical analysis is carried out for the steady-state response of a one-dimensional wave-bearing system formed from two identical subsystems coupled together at an end with a general coupling. The statistics correspond approximately to averaging in frequency.

PARAMETER IDENTIFICATION

81-201

Parametric Time Domain Analysis of the Multiple Input/Scalar Output Problem: The Source Identification Problem

W. Gersch, T. Brotherton, and S. Braun
Dept. of Information and Computer Sciences, Univ. of Hawaii, Honolulu, Hawaii 96822, J. Sound Vib., 69 (3), pp 441-460 (Apr 8, 1980) 5 figs, 1 table, 19 refs

Key Words: Parameter identification technique, Time domain method

A multiple input/scalar output stationary time series identification problem is considered from a parametric model time domain point of view. Particular emphasis is on the source identification problem. Closed form formula estimates of the individual source power contributions are expressed in terms of sample correlations that are obtained from the observed input and output time series and from parametric models fitted to that data.

81-202

New Algorithms for Nonlinear Least Squares and Bayesian Parameter Estimation

W.E. Stewart and J.P. Sorensen
Mathematics Res. Ctr., Wisconsin Univ., Madison, WI, Rept. No. MRC-TSR-2037, 27 pp (Feb 1980) AD-A083 819/3

Key Words: Algorithms, Parameter identification technique, Least squares method

New algorithms are presented for fitting mathematical models to multiple-response experiments. These algorithms give estimates of the parameters in a user-defined predictor model, and also estimate the parameters of a Gaussian model of the observational error distribution.

81-203

On Predicting Point Mobility Plots from Measurements of Other Mobility Parameters

D.J. Ewins
Dept. of Mech. Engrg., Imperial College of Science and Tech., Exhibition Rd., London SW7 2BX, UK, J. Sound Vib., 70 (1), pp 69-75 (May 8, 1980) 3 figs, 6 refs

Key Words: Modal analysis, Parameter identification technique, Mathematical models

Experimental modal analysis techniques are designed to exploit a property of linear vibration theory in order to construct a mathematical model of a structure from the minimum amount of measured mobility data. This property, derived from the orthogonality of normal modes, is that, in principle, all the elements of the full N x N mobility matrix can be derived from measurement of the elements in just one row or column of that matrix. The property is also used in procedural quality "checks", in which one measures some of the derived mobilities as well as predicting them. The derivation process itself, however, gives rise to an inherent error when the frequency range covered does not include all the natural frequencies of the structure. The source of this error is discussed and some illustrations of its significance are quoted, demonstrating the need for caution when applying modal analysis methods to practical structures.

COMPUTER PROGRAMS

(Also see Nos. 5, 22, 46, 74)

81-204

High Speed Cylindrical Rolling Element Bearing Analysis "CYBEAN" - Analytic Formulation

R.J. Kleckner, J. Pirvics, and V. Castelli
Xerox Corp., El Segundo, CA, J. Lubric. Tech., Trans. ASME, 102 (3), pp 380-388 (July 1980) 7 figs, 3 tables, 2 refs

Key Words: Computer programs, Bearings, Antifriction bearings, Transient response, Periodic response

The analytic foundation and software architecture for the computerized mathematical simulation of high speed cylindrical rolling element bearing behavior is documented. The software, CYBEAN (CYlindrical BEaring ANalysis), considers a flexible, variable geometry outer ring, EHD films, roller centrifugal and quasidynamic loads, roller tilt and skew, mounting fits, cage and flange interactions.

81-205

A Time-Sharing Computer Program to Drive up to Three Independent Fatigue Testing Machines

W. Watt

Royal Aircraft Establishment, Farnborough, UK, Rept. No. RAE-TR-79054, DRIC-BR-70107, 32 pp (May 1979)
AD-A085 488/5

Key Words: Computer programs, Fatigue tests, Test equipment and instrumentation, Computer-aided techniques

WG is a PDP-8/E computer program which offers a choice from seven resident software sequence generators to each of three independent hardware waveform controllers which drive electrohydraulic fatigue testing machines. The program is controlled by teletype commands and paper tape input data.

81-206
TOFC (Trailer on Flatcar) Lading Response Analyses for Several Track Profile and Hunting Conditions
G. Kachadourian
Metrek Div., Mitre Corp., McLean, VA, Rept. No. MTR-79W00318, FRA/ORD-80/3, 73 pp (Apr 1980)
PB80-178171

Key Words: Computer programs, Railroad cars, Freight cars, Interaction: rail-vehicle

The computer program FRATE is a non-linear, time domain digital computer program developed for the purpose of studying freight car response dynamics. Analyses were performed to obtain the response of a trailer on flatcar (TOFC) vehicle and compliant lading to several track profiles and body hunting conditions.

81-207
Response Analyses of a Boxcar with Compliant Lading for Several Track Profile and Hunting Conditions
G. Kachadourian and N.E. Sussman
Metrek Div., Mitre Corp., McLean, VA, Rept. No. MTR-79W00317, FRA/ORD-80/4, 90 pp (Apr 1980)
PB80-177637

Key Words: Computer programs, Railroad cars, Freight cars, Interaction: rail-wheel

The simulation in the FRATE computer program (Freight Car Response Analysis and Test Evaluation) was modified from a flexible TOFC (trailer on flatcar) to a rigid boxcar with compliant lading. Analyses were performed to obtain the response of boxcar elements and compliant lading to several track profile and body hunting conditions.

GENERAL TOPICS

CONFERENCE PROCEEDINGS

81-208
Flow-Induced Vibration of Power Plant Components
The Pressure Vessels and Piping Conf., PVP No. 41, Aug 12-15, 1980, San Francisco, CA, M.K. Au-Yang, ed., ASME: 1980

Key Words: Proceedings, Fluid-induced excitation, Electric power plants, Heat exchangers, Pipes (tubes)

This symposium covers a wide range of structural dynamics problems associated with the power generation industry during both normal operations and hypothetical accident conditions. Eight of the eleven papers deal with flow induced vibrations in tube banks and bundles. Abstracts of individual pertinent articles are listed in the appropriate section of this issue of the DIGEST.

81-209
Bearing Design - Historical Aspects, Present Technology and Future Problems
Intl. Conf., Aug 18-21, 1980, San Francisco, CA, W.J. Anderson, ed., ASME: 1980

Key Words: Bearings, Design techniques, Proceedings

These papers deal with some of the more important present day and future bearing requirements, and design methodologies available for coping with them. Solutions to many forthcoming bearing problems lie in the utilization of the most advanced materials, design methods and lubrication techniques. Abstracts of individual pertinent papers are listed in the appropriate sections of this issue of the DIGEST.

81-210

Emerging Technologies in Aerospace Structures, Design, Structural Dynamics and Materials

Aerospace Conf., Aug 13-15, 1980, San Francisco, CA, J.R. Vinson, ed., ASME: 1980

Key Words: Proceedings, Spacecraft, Aircraft, Composite materials, Design techniques

This collection of papers concentrates on the newest developments in the closely related fields of aerospace structures, design, structural dynamics, shock and impact, as well as material science, particularly composite materials. Abstracts of pertinent individual papers are listed in the appropriate sections of this issue of the DIGEST.

81-211

Reliability, Stress Analysis and Failure Prevention Methods in Mechanical Design

Intl. Conf., Aug 18-21, 1980, San Francisco, CA, W.D. Milestone, ed., ASME: 1980

Key Words: Proceedings, Monitoring techniques, Fatigue life, Machinery components

The papers contained in this special publication deal with the techniques and methodologies used to predict reliability, stress analysis and failure in mechanical devices and systems. Session titles at this conference included: "Materials Factors in Reliability," "Failure Prevention via Mechanical Signature Analysis," "Reliability Assurance: Aprior and Aposteriori Tasks," "Failure Prediction and Reliability: Selected Case Studies," "Research Needs in Reliability and Failure Prevention," "Stress Analysis in Machine Components," "Fatigue and Fracture Mechanics." and "Fatigue and Nonlinear Stress Analysis." Abstracts of individual pertinent papers are listed in the appropriate sections of this issue of the DIGEST.

TUTORIALS AND REVIEWS

81-212

Vibration in Jet Engines

M. Lalanne

Laboratoire de Mecanique des Structures, I.N.S.A., 20, avenue Albert Einstein, 69621 Villeurbanne, France, Shock Vib. Dig., 12 (9), pp 3-9 (Sept 1980) 1 fig, 75 refs

Key Words: Reviews, Jet engines, Engine vibrations, Vibration control, Vibration prediction, Blades, Rotors (machine elements)

Vibration in jet engines is reviewed, oriented toward prediction of the behavior of blades, disc blades, axisymmetric structures, and rotors and toward the possibilities of vibration control.

81-213

Squeeze-Film Damping of Rotordynamic Systems

R. Holmes

School of Engrg. and Applied Science, Univ. of Sussex, Falmer, Brighton, Sussex BN1 9QT, UK, Shock Vib. Dig., 12 (9), pp 11-15 (Sept 1980) 3 figs, 10 refs

Key Words: Reviews, Damping, Squeeze-film dampers, Vibration isolators, Rotating Structures

The roles of the squeeze-film damper when used in parallel with a flexible element in a vibration isolator and when used in series with flexible pedestals or frame of a rotordynamic system are described.

81-214

Pneumatic Shock Absorbers and Isolators

M.S. Hundal

Univ. of Vermont, Burlington, VT 05405, Shock Vib. Dig., 12 (9), pp 17-21 (Sept 1980) 9 figs, 7 refs

Key Words: Reviews, Dampers, Pneumatic dampers, Vibration absorption (equipment), Vibration isolators, Shock absorbers

Literature published in the last several years on shock absorbers and isolators that utilize pneumatic dampers is reviewed. Topics for further investigation are mentioned.

81-215

Equivalence Techniques for Vibration Testing

H.S. Blanks

School of Electrical Engrg., Univ. of New South Wales, P.O. Box 1, Kensington, New South Wales, Australia 2033, Shock Vib. Dig., 12 (8), pp 13-23 (Aug 1980) 128 refs

AUTHOR INDEX

Key Words: Reviews, Vibration tests, Testing techniques, Equivalence principle

This survey considers techniques relevant to the equivalence between vibration tests and service vibration experience. It is intended to convey a picture of the state of the art; most of the references were published after 1975.

CRITERIA, STANDARDS, AND SPECIFICATIONS

(Also see Nos. 24, 155)

81-216

Proposed Uniform Building Code Seismic Risk Zone Revision in Southeast Idaho

J.G. Arendts, V.W. Gorman, R.C. Guenzler, and L.G. Miller

EG and G Idaho, Inc., Idaho Falls, ID, 17th Annual Symp. Engrg. Geology and Soils Engrg., Boise, ID, USA, Apr 2, 1980, 38 pp (1979)

CONF-800412-1

Key Words: Standards and codes, Seismic design

Scientific evidence is utilized to propose a revised uniform building code seismic risk zone map for Southeastern Idaho. Regional geological information, including known and suspected faults, is presented. A comprehensive summary of magnitude and location of recorded regional earthquake epicenters and their relation to the proposed UBC seismic zone modification is presented.

81-217

Recommended Revisions to Nuclear Regulatory Commission Seismic Design Criteria

D.W. Coats

Lawrence Livermore Lab., California Univ., Livermore, CA, 224 pp (May 1980)

NUREG/CR-1161

Key Words: Nuclear power plants, Seismic design, Regulations

This report recommends changes in the Nuclear Regulatory Commission's (NRC's) criteria now used in the seismic design of nuclear power plants. Areas covered include ground motion, soil-structure interaction, structures, and equipment and components. Members of the Engineering Mechanics Section of the Nuclear Test Engineering Division at Lawrence Livermore Laboratory (LLL) generally agreed upon the recommendations, which are based on (1) reports developed under the NRC's Task Action Plan A-40, (2) other available engineering literature, and (3) recommendations of nationally recognized experts retained by LLL specifically for this task.

PERIODICALS SCANNED

PUBLICATION AND ADDRESS	ABBREVIATION
ACTA MECHANICA Springer-Verlag New York, Inc. 175 Fifth Ave. New York, NY 10010	Acta Mech.
ACUSTICA S. Hirzel Verlag, Postfach 347 D-700 Stuttgart 1 W. Germany	Acustica
AERONAUTICAL JOURNAL Royal Aeronautical Society 4 Hamilton Place London W1V 0BQ, UK	Aeronaut. J.
AERONAUTICAL QUARTERLY Royal Aeronautical Society 4 Hamilton Place London W1V 0BQ, UK	Aeronaut. Quart.
AIAA JOURNAL American Institute of Aeronautics and Astronautics 1290 Avenue of the Americas New York, NY 10019	AIAA J.
AMERICAN SOCIETY OF CIVIL ENGINEERS, PROCEEDINGS ASCE United Engineering Center 345 East 47th St. New York, NY 10017	
JOURNAL OF ENGINEERING MECHANICS DIVISION	ASCE J. Engrg. Mechanics Div.
JOURNAL OF STRUCTURAL DIVISION	ASCE J. Struc. Div.
AMERICAN SOCIETY OF LUBRICATING ENGINEERS, TRANSACTIONS Academic Press 111 Fifth Ave. New York, NY 10019	ASLE, Trans.
AMERICAN SOCIETY OF MECHANICAL ENGINEERS, TRANSACTIONS ASME United Engineering Center 345 East 47th St. New York, NY 10017	
JOURNAL OF APPLIED MECHANICS	J. Appl. Mechanics, Trans. ASME
JOURNAL OF DYNAMIC SYSTEMS, MEASUREMENT AND CONTROL	J. Dyn. Syst., Meas. and Control, Trans. ASME
JOURNAL OF ENGINEERING FOR INDUSTRY	J. Engrg. Indus., Trans. ASME
JOURNAL OF ENGINEERING FOR POWER	J. Engrg. Power, Trans. ASME
JOURNAL OF ENGINEERING RESOURCES TECHNOLOGY	J. Engrg. Resources Tech., Trans. ASME
JOURNAL OF LUBRICATION TECHNOLOGY	J. Lubric. Tech., Trans. ASME
JOURNAL OF MECHANICAL DESIGN	J. Mech. Des., Trans. ASME
JOURNAL OF PRESSURE VESSEL TECHNOLOGY	J. Pressure Vessel Tech., Trans. ASME
APPLIED ACOUSTICS Applied Science Publishers, Ltd. Ripple Road, Barking Essex, UK	Appl. Acoust.
ARCHIVES OF MECHANICS (ARCHIWUM MECHANIKI STOSOWANEJ) Export and Import Enterprise Ruch UL, Wronia 23, Warsaw, Poland	Arch. Mechanics
ASTRONAUTICS AND AERONAUTICS AIAA EDP 1290 Avenue of the Americas New York, NY 10019	Astronaut. & Aeronaut.
AUTOMOBILTECHNISCHE ZEITSCHRIFT Franckh'sche Verlagshandlung Abteilung Technik 7000 Stuttgart 1 Pfizerstrasse 5-7 W. Germany	Automobiltech. Z.
AUTOMOTIVE ENGINEER (SAE) Society of Automotive Engineers, Inc. 400 Commonwealth Drive Warrendale, PA 15096	Auto. Engr. (SAE)
AUTOMOTIVE ENGINEER (UK) P.O. Box 24, Northgate Ave. Bury St., Edmunds Suffolk IP21 GBW, UK	Auto. Engr. (UK)
BALL BEARING JOURNAL (English Edition) SKF (U.K.) Ltd. Luton, Bedfordshire LU3 1JF, UK	Ball Bearing J.
BROWN BOVERI REVIEW Brown Boveri and Co., Ltd. CH-5401, Baden, Switzerland	Brown Boveri Rev.
BULLETIN DE L'ACADEMIE POLONAISE DES SCIENCES, SERIES DES SCIENCES TECHNIQUES Ars Polona-Ruch 7 Krokowskie Przedmiescie, Poland	Bull. Acad. Polon. Sci., Ser. Sci. Tech.

PUBLICATION AND ADDRESS	ABBREVIATION
BULLETIN OF JAPAN SOCIETY OF MECHANICAL ENGINEERS Japan Society of Mechanical Engineers Sanshin Hokusei Bldg. H-9 Yoyogi 2-chome Shibuya-ku Tokyo 151, Japan	Bull. JSME
BULLETIN OF SEISMOLOGICAL SOCIETY OF AMERICA Bruce A. Bolt Box 826 Berkeley, CA 94705	Bull. Seismol. Soc. Amer.
CIVIL ENGINEERING (NEW YORK) ASCE United Engineering Center 345 E. 47th St. New York, NY 10017	Civ. Engrg. (N.Y.)
CLOSED LOOP MTS Systems Corp. P.O. Box 24012 Minneapolis, MN 55474	Closed Loop
COMPUTERS AND STRUCTURES Pergamon Press Inc. Maxwell House, Fairview Park Elmsford, NY 10523	Computers Struc.
DESIGN ENGINEERING Berkshire Common Pittsfield, MA 02101	Des. Engrg.
DESIGN NEWS Cahners Publishing Co., Inc. 221 Columbus Ave. Boston, MA 02116	Des. News
DIESEL AND GAS TURBINE PROGRESS Diesel Engines, Inc. P.O. Box 7406 Milwaukee, WI 53213	Diesel Gas Turbine Prog.
ENGINEERING MATERIALS AND DESIGN IPC Industrial Press Ltd. 33-40 Bowling Green Lane London EC1R, UK	Engrg. Mtl. Des.
ENGINEERING STRUCTURES IPC Science and Technology Press Ltd. Westbury House P.O. Box 63, Bury Street Guildford, Surrey GU2 5BH, UK	Engrg. Struc.
EXPERIMENTAL MECHANICS Society for Experimental Stress Analysis 21 Bridge Sq., P.O. Box 277 Westport, CT 06880	Exptl. Mechanics
FEINWERK U. MESSTECHNIK Carl Hanser GmbH & Co. D-800 Munchen 86 Postfach 860420 Fed. Rep. Germany	Feinwerk u. Messtechnik
FORSCHUNG IM INGENIEURWESEN Verein Deutscher Ingenieur, GmbH Postfach 1139 Graf-Recke Str. 84 4 Düsseldorf 1 W. Germany	Forsch. Ingenieurwesen
HEATING/PIPING/AIR CONDITIONING Circulation Dept. 614 Superior Ave. West Cleveland, OH 44113	Heating/ Piping/ Air Cond.
HYDRAULICS AND PNEUMATICS Penton/IPC, Inc. 614 Superior Ave. West Cleveland, OH 44113	Hydraulics & Pneumatics
HYDROCARBON PROCESSING Gulf Publishing Co. Box 2608 Houston, TX 77001	Hydrocarbon Processing
IBM JOURNAL OF RESEARCH AND DEVELOPMENT International Business Machines Corp. Armonk, NY 10504	IBM J. Res. Dev.
INDUSTRIAL RESEARCH Dun-Donnelley Publishing Corp. 222 S. Riverside Plaza Chicago, IL 60606	Indus. Res.
INGENIEUR-ARCHIV Springer-Verlag New York, Inc. 175 Fifth Ave. New York, NY 10010	Ing. Arch.
INSTITUTE OF ELECTRICAL AND ELECTRONICS ENGINEERS IEEE United Engineering Center 345 East 47th St. New York, NY 10017	IEEE
INSTITUTION OF MECHANICAL ENGINEERS, (LONDON), PROCEEDINGS Institution of Mechanical Engineers 1 Birdcage Walk, Westminster, London SW1, UK	IMechE Proc.
INSTRUMENT SOCIETY OF AMERICA, TRANSACTIONS Instrument Society of America 400 Stanwix St. Pittsburgh, PA 15222	ISA Trans
INSTRUMENTATION TECHNOLOGY Instrument Society of America 67 Alexander Drive P.O. Box 12277 Research Triangle Park, NC 27709	InTech.
INTERNATIONAL JOURNAL OF CONTROL Taylor and Francis Ltd. 10-14 Macklin St. London WC2B 5NF, UK	Intl. J. Control
INTERNATIONAL JOURNAL OF EARTHQUAKE ENGINEERING AND STRUCTURAL DYNAMICS John Wiley and Sons, Ltd. 650 Third Ave. New York, NY 10016	Intl. J. Earthquake Engrg. Struc. Dynam.
INTERNATIONAL JOURNAL OF ENGINEERING SCIENCES Pergamon Press Inc. Maxwell House, Fairview Park Elmsford, NY 10523	Intl. J. Engrg. Sci.

PUBLICATION AND ADDRESS	ABBREVIATION
INTERNATIONAL JOURNAL OF FATIGUE IPI Science and Technology Press Ltd. P.O. Box 63, Westbury House, Bury Street Guildford, Surrey, England GU2 5BH	Intl. J. Fatigue
INTERNATIONAL JOURNAL OF MACHINE TOOL DESIGN AND RESEARCH Pergamon Press Inc. Maxwell House, Fairview Park Elmsford, NY 10523	Intl. J. Mach. Tool Des. Res.
INTERNATIONAL JOURNAL OF MECHANICAL SCIENCES Pergamon Press, Inc. Maxwell House, Fairview Park Elmsford, NY 10523	Intl. J. Mech. Sci.
INTERNATIONAL JOURNAL OF NONLINEAR MECHANICS Pergamon Press Inc. Maxwell House, Fairview Park Elmsford, NY 10523	Intl. J. Nonlin. Mechanics
INTERNATIONAL JOURNAL FOR NUMERICAL METHODS IN ENGINEERING John Wiley and Sons, Ltd. 605 Third Ave. New York, NY 10016	Intl. J. Numer. Methods Engrg.
INTERNATIONAL JOURNAL FOR NUMERICAL AND ANALYTICAL METHODS IN GEOMECHANICS John Wiley and Sons, Ltd. Baffins Lane Chichester, Sussex, UK	Intl. J. Numer. Anal. Methods Geomech.
INTERNATIONAL JOURNAL OF SOLIDS AND STRUCTURES Pergamon Press Inc. Maxwell House, Fairview Park Elmsford, NY 10523	Intl. J. Solids Struc.
INTERNATIONAL JOURNAL OF VEHICLE DESIGN The International Assoc. of Vehicle Design The Open University, Walton Hall Milton Keys MK7 6AA, UK	Intl. J. Vehicle Des.
ISRAEL JOURNAL OF TECHNOLOGY Weizmann Science Press of Israel Box 801 Jerusalem, Israel	Israel J. Tech.
JOURNAL OF THE ACOUSTICAL SOCIETY OF AMERICA American Institute of Physics 335 E. 45th St. New York, NY 10010	J. Acoust. Soc. Amer.
JOURNAL OF AIRCRAFT American Institute of Aeronautics and Astronautics 1290 Avenue of the Americas New York, NY 10019	J. Aircraft
JOURNAL OF THE AMERICAN HELICOPTER SOCIETY American Helicopter Society, Inc. 30 East 42nd St. New York, NY 10017	J. Amer. Helicopter Soc.
JOURNAL OF ENGINEERING MATHEMATICS Academic Press 198 Ash Street Reading, MA 01867	J. Engrg. Math.
JOURNAL OF ENVIRONMENTAL SCIENCES Institute of Environmental Sciences 940 E. Northwest Highway Mt. Prospect, IL 60056	J. Environ. Sci.
JOURNAL OF FLUID MECHANICS Cambridge University Press 32 East 57th St. New York, NY 10022	J. Fluid Mechanics
JOURNAL OF THE FRANKLIN INSTITUTE Pergamon Press Inc. Maxwell House, Fairview Park Elmsford, NY 10523	J. Franklin Inst.
JOURNAL OF HYDRONAUTICS American Institute of Aeronautics and Astronautics 1290 Avenue of the Americas New York, NY 10019	J. Hydro-nautics
JOURNAL OF THE INSTITUTE OF ENGINEERS, AUSTRALIA Science House, 157 Gloucter Sydney, Australia 2000	J. Inst. Engr., Austral.
JOURNAL DE MECANIQUE Gauthier-Villars C.D.R. - Centrale des Revues B.P. No. 119, 93104 Montreuil Cedex-France	J. de mecanique
JOURNAL OF MECHANICAL ENGINEERING SCIENCE Institution of Mechanical Engineers 1 Birdcage Walk, Westminster London SW1 H9, UK	J. Mech. Engrg. Sci.
JOURNAL OF THE MECHANICS AND PHYSICS OF SOLIDS Pergamon Press Inc. Maxwell House, Fairview Park Elmsford, NY 10523	J. Mechanics Phys. Solids
JOURNAL OF PETROLEUM TECHNOLOGY Society of Petroleum Engineers 6200 N. Central Expressway Dallas, TX 75206	J. Pet. Tech.
JOURNAL OF PHYSICS: E SCIENTIFIC INSTRUMENTS American Institute of Physics 335 East 45th St. New York, NY 10017	J. Phys. E: Sci. Instrum.
JOURNAL OF SHIP RESEARCH Society of Naval Architects and Marine Engineers 20th and Northhampton Sts. Easton, PA 18042	J. Ship Res.
JOURNAL OF SOUND AND VIBRATION Academic Press 111 Fifth Ave. New York, NY 1001?	J. Sound Vib.

PUBLICATION AND ADDRESS	ABBREVIATION
JOURNAL OF SPACECRAFT AND ROCKETS American Institute of Aeronautics and Astronautics 1290 Avenue of the Americas New York, NY 10019	J. Spacecraft Rockets
JOURNAL OF TESTING AND EVALUATION (ASTM) American Society for Testing and Materials 1916 Race St. Philadelphia, PA 19103	J. Test Eval. (ASTM)
KONSTRUKTION Spring Verlag 3133 Connecticut Ave., N.W. Suite 712 Washington, D.C. 20008	Konstruktion
LUBRICATION ENGINEERING American Society of Lubrication Engineers 838 Busse Highway Park Ridge, IL 60068	Lubric. Engrg.
MACHINE DESIGN Penton Publishing Co. Penton Bldg. Cleveland, OH 44113	Mach. Des.
MASCHINENBAUTECHNIK VEB Verlag Technik Oranienburger Str. 13/14 102 Berlin, E. Germany	Maschinenbautechnik
MECCANICA Pergamon Press, Inc. Maxwell House, Fairview Park Elmsford, NY 10523	Meccanica
MECHANICAL ENGINEERING American Society of Mechanical Engineers 345 East 45th St. New York, NY 10017	Mech. Engrg.
MECHANICS RESEARCH AND COMMUNICATIONS Pergamon Press Inc. Maxwell House, Fairview Park Elmsford, NY 10523	Mechanics Res. Comm.
MECHANISM AND MACHINE THEORY Pergamon Press Inc. Maxwell House, Fairview Park Elmsford, NY 10523	Mech. Mach. Theory
MEMOIRES OF THE FACULTY OF ENGINEERING, KYOTO UNIVERSITY Kyoto University Kyoto, Japan	Mem. Fac. Engrg. Kyoto Univ.
MTZ MOTORTECHNISCHE ZEITSCHRIFT Franckh'sche Verlagshandlung Pfizerstrasse 5-7 7000 Stuttgart 1 W. Germany	MTZ Motortech. Z.
NAVAL ENGINEERS JOURNAL American Society of Naval Engineers, Inc. Suite 507, Continental Bldg. 1012 - 14th St., N.W. Washington, D.C. 20005	Naval Engr. J.
NOISE AND VIBRATION CONTROL Trade and Technical Press Ltd. Crown House, Morden Surrey SM4 5EW, UK	Noise Vib. Control
NOISE CONTROL ENGINEERING P.O. Box 3206, Arlington Branch Poughkeepsie, NY 12603	Noise Control Engrg.
NORTHEAST COAST INSTITUTION OF ENGINEERS AND SHIPBUILDERS, TRANSACTIONS Bolbec Hall Newcastle upon Tyne 1, UK	NE Coast Instn. Engrs. Shipbldrs., Trans.
NUCLEAR ENGINEERING AND DESIGN North Holland Publishing Co. P.O. Box 3489 Amsterdam, The Netherlands	Nucl. Engrg. Des.
OIL AND GAS JOURNAL The Petroleum Publishing Co. 211 S. Cheyenne Tulsa, OK 74101	Oil Gas J.
PACKAGE ENGINEERING 5 S. Wabash Ave. Chicago, IL 60603	Package Engrg.
PLANT ENGINEERING 1301 S. Grove Avenue Barrington, IL 60010	Plant Engrg.
POWER P.O. Box 521 Hightston, NJ 08520	Power
POWER TRANSMISSION DESIGN Industrial Publishing Co. Division of Pittway Corp. 812 Huron Rd. Cleveland, OH 44113	Power Transm. Des.
QUARTERLY JOURNAL OF MECHANICS AND APPLIED MATHEMATICS Wm. Dawson & Sons, Ltd. Cannon House Folkestone, Kent, UK	Quart. J. Mechanics Appl. Math.
REVUE ROUMAINE DES SCIENCES TECHNIQUES, SERIE DE MECANIQUE APPLIQUEE Editions De L'Academie De La Republique Socialiste de Roumaine 3 Bis Str., Gutenberg, Bucurest, Romania	Rev. Roumaine Sci. Tech., Mecanique Appl.
REVIEW OF SCIENTIFIC INSTRUMENTS American Institute of Physics 335 East 45th St. New York, NY 10017	Rev. Scientific Instr.
SAE PREPRINTS Society of Automotive Engineers Two Pennsylvania Plaza New York, NY 10001	SAE Prepr.
SIAM JOURNAL ON APPLIED MATHEMATICS Society for Industrial and Applied Mathematics 33 S. 17th St. Philadelphia, PA 19103	SIAM J. Appl. Math.

PUBLICATION AND ADDRESS	ABBREVIATION
SIAM JOURNAL ON NUMERICAL ANALYSIS Society for Industrial and Applied Mathematics 33 S. 17th St. Philadelphia, PA 19103	SIAM J. Numer. Anal.
STROJNICKY ČASOPIS Red. Strojnickeno Casopisu ČSAV A SAV USTAV MECHANIKY STROJOV SAV Bratislava-Patronka, Dubrovska cesta, ČSSR Czechoslovakia	Strojnicky Časopis
S/V, SOUND AND VIBRATION Acoustic Publications, Inc. 27101 E. Oviat Rd. Bay Village, OH 44140	S/V, Sound Vib.
TECHNISCHES MESSEN - ATM R. Oldenburg Verlag GmbH Rosenheimer Str. 145 8 München 80, W. Germany	Techn. Messen-ATM
TEST 61 Monmouth Road Oakhurst, NJ 07755	Test
TRIBOLOGY INTERNATIONAL IPC Science and Technology Press Ltd. Westbury House P.O. Box 63, Bury Street Guildford, Surrey GU2 5BH, UK	Tribology Intl.
TURBOMACHINERY INTERNATIONAL Turbomachinery Publications, Inc. 22 South Smith St. Norwalk, CT 06855	Turbomach. Intl.
VDI ZEITSCHRIFT Verein Deutscher Ingenieur GmbH Postfach 1139, Graf-Recke Str. 84 4 Düsseldorf 1, Germany	VDI Z.
VDI FORSCHUNGSHEFT Verein Deutscher Ingenieur GmbH Postfach 1139, Graf-Recke Str. 84 4 Düsseldorf 1, Germany	VDI Forsch.
VEHICLE SYSTEMS DYNAMICS Swets and Zeitlinger N.V. 347 B. Herreweg Lisse, The Netherlands	Vehicle Syst. Dyn.
VIBROTECHNIKA Kauno Polytechnikos Institutas 2 Donelaičio g-ve 17 233000 Kaunas Lithuanian SSR	Vibro-technika
WAVE MOTION North Holland Publishing Co. P.O. Box 211 1000 AE Amsterdam The Netherlands	Wave Motion
WEAR Elsevier Sequoia S.A. P.O. Box 851 1001 Lausanne 1, Switzerland	Wear
ZEITSCHRIFT FÜR ANGEWANDTE MATHEMATIK UND MECHANIK Akademie Verlag GmbH Liepziger Str. 3-4 108 Berlin, Germany	Z. angew. Math. Mech.
ZEITSCHRIFT FÜR FLUGWISSENSCHAFTEN DFVLR D-3300 Braunschweig Flughafen, Postfach 3267 W. Germany	Z. Flugwiss

SECONDARY PUBLICATIONS SCANNED

GOVERNMENT REPORTS ANNOUNCEMENTS & INDEX NTIS U.S. Dept. of Commerce Springfield, VA 22161	GRA
SCIENTIFIC AND TECHNICAL AEROSPACE REPORTS Superintendent of Documents U.S. Government Printing Office Washington, D.C. 20402	STAR
DISSERTATION ABSTRACTS INTERNATIONAL University Microfilms Ann Arbor, MI 48106	DA

ANNUAL PROCEEDINGS SCANNED

INSTITUTE OF ENVIRONMENTAL SCIENCES, ANNUAL PROCEEDINGS Institute of Environmental Sciences 940 E. Northwest Highway Mt. Prospect, IL 60056	Inst. Environ. Sci., Proc.
TURBOMACHINERY SYMPOSIUM Gas Turbine Labs Texas A&M University College Station, Texas	Turbomach. Symp.
THE SHOCK AND VIBRATION BULLETIN, UNITED STATES NAVAL RESEARCH LABORATORIES, ANNUAL PROCEEDINGS Shock and Vibration Information Center Naval Research Lab., Code 5804 Washington, D.C. 20375	Shock Vib. Bull., U.S. Naval Res. Lab., Proc.

CALENDAR

MARCH 1981

8-12 26th International Gas Turbine Conference and Exhibit [ASME] Houston, TX *(ASME Hq.)*

21-Apr 1 Lubrication Symposium [ASME] San Francisco, CA *(ASME Hq.)*

31-Apr 1 Pressworking Machinery for the Eighties Conference [IMechE] Birmingham, UK *(IMechE, 1 Birdcage Walk, Westminster, London SW1H 9JJ)*

APRIL 1981

6-8 22nd Structures, Structural Dynamics, and Materials Conference [AIAA, ASME, ASCE, AHS] Atlanta, Georgia *(AIAA, ASME, ASCE, AHS Hqs.)*

6-8 NOISEXPO '81 [S/V, Sound and Vibration] Hyatt Regency O'Hare, Chicago, IL *(NOISEXPO '81, 27101 E. Oviatt Rd., Bay Village, OH 44140)*

27-30 27th Intl. Instrumentation Symposium [Aerospace Industries and Test Measurement Divisions of the Instrument Society of America] Hyatt Regency, Indianapolis, IN *(Jim Dorsey, c/o Measurements Group, P.O. Box 27777, Raleigh, NC 27611)*

MAY 1981

4-7 Institute of Environmental Sciences' 27th Annual Technical Meeting [IES] Los Angeles, CA *(IES, 940 East Northwest Highway, Mt. Prospect, IL 60056)*

31-Jun 5 Spring Meeting and Exhibition of the Society for Experimental Stress Analysis [SESA] Hyatt Regency, Dearborn, MI *(SESA, P.O. Box 277, Saugatuck Station, Westport, CT 06880)*

JUNE 1981

1-4 Design Engineering Conference and Show [ASME] Chicago, IL *(ASME Hq.)*

8-10 NOISE-CON 81 [Institute of Noise Control Engineering and the School of Engineering, North Carolina State University] Raleigh, North Carolina *(Dr. Larry Royster, Program Chairman, Center for Acoustical Studies, Dept. of Mechanical & Aerospace Engr., North Carolina State University, Raleigh, NC 27650)*

22-24 Applied Mechanics Conference [ASME] Boulder, CO *(ASME Hq.)*

SEPTEMBER 1981

1-4 Joint Meeting of the British Society for Strain Measurement and the Society for Experimental Stress Analysis [B.S.S.M. and SESA] Edinburgh University, Scotland *(C. McCalvey, Administration Officer, B.S.S.M., 281 Heaton Road, Newcastle upon Tyne, NE6, 50B, UK)*

20-23 Design Engineering Technical Conference [ASME] Hartford, CT *(ASME Hq.)*

OCTOBER 1981

Eastern Design Engineering Show [ASME] New York, NY *(ASME Hq.)*

4-7 International Lubrication Conference [ASME - ASLE] New Orleans, LA *(ASME Hq.)*

11-15 Fall Meeting of the Society for Experimental Stress Analysis [SESA] Keystone Resort, Keystone, CO *(SESA, P.O. Box 277, Saugatuck Station, Westport, CT 06880)*

NOVEMBER 1981

15-20 ASME Winter Annual Meeting [ASME] Washington, D.C. *(ASME Hq.)*

30-Dec 4 Acoustical Society of America, Fall Meeting [ASA] Miami Beach, FL *(ASA Hq.)*

DECEMBER 1981

8-10 Western Design Engineering Show [ASME] Anaheim, CA *(ASME Hq.)*

CALENDAR ACRONYM DEFINITIONS AND ADDRESSES OF SOCIETY HEADQUARTERS

AFIPS: American Federation of Information Processing Societies
210 Summit Ave., Montvale, NJ 07645

AGMA: American Gear Manufacturers Association
1330 Mass. Ave., N.W.
Washington, D.C.

AHS: American Helicopter Society
1325 18 St. N.W.
Washington, D.C. 20036

AIAA: American Institute of Aeronautics and Astronautics, 1290 Sixth Ave.
New York, NY 10019

AIChE: American Institute of Chemical Engineers
345 E. 47th St.
New York, NY 10017

AREA: American Railway Engineering Association
59 E. Van Buren St.
Chicago, IL 60605

ARPA: Advanced Research Projects Agency

ASA: Acoustical Society of America
335 E. 45th St.
New York, NY 10017

ASCE: American Society of Civil Engineers
345 E. 45th St.
New York, NY 10017

ASME: American Society of Mechanical Engineers
345 E. 45th St.
New York, NY 10017

ASNT: American Society for Nondestructive Testing
914 Chicago Ave.
Evanston, IL 60202

ASQC: American Society for Quality Control
161 W. Wisconsin Ave.
Milwaukee, WI 53203

ASTM: American Society for Testing and Materials
1916 Race St.
Philadelphia, PA 19103

CCCAM: Chairman, c/o Dept. ME, Univ. Toronto,
Toronto 5, Ontario, Canada

ICF: International Congress on Fracture
Tohoku Univ.
Sendai, Japan

IEEE: Institute of Electrical and Electronics Engineers
345 E. 47th St.
New York, NY 10017

IES: Institute of Environmental Sciences
940 E. Northwest Highway
Mt. Prospect, IL 60056

IFToMM: International Federation for Theory of Machines and Mechanisms
U.S. Council for TMM
c/o Univ. Mass., Dept. ME
Amherst, MA 01002

INCE: Institute of Noise Control Engineering
P.O. Box 3206, Arlington Branch
Poughkeepsie, NY 12603

ISA: Instrument Society of America
400 Stanwix St.
Pittsburgh, PA 15222

ONR: Office of Naval Research
Code 40084, Dept. Navy
Arlington, VA 22217

SAE: Society of Automotive Engineers
400 Commonwealth Drive
Warrendale, PA 15096

SEE: Society of Environmental Engineers
6 Conduit St.
London W1R 9TG, UK

SESA: Society for Experimental Stress Analysis
21 Bridge Sq.
Westport, CT 06880

SNAME: Society of Naval Architects and Marine Engineers
74 Trinity Pl.
New York, NY 10006

SPE: Society of Petroleum Engineers
6200 N. Central Expressway
Dallas, TX 75206

SVIC: Shock and Vibration Information Center
Naval Research Lab., Code 5804
Washington, D.C. 20375

URSI-USNC: International Union of Radio Science - U.S. National Committee
c/o MIT Lincoln Lab.
Lexington, MA 02173

PUBLICATION POLICY

Unsolicited articles are accepted for publication in the Shock and Vibration Digest. Feature articles should be tutorials and/or reviews of areas of interest to shock and vibration engineers. Literature review articles should provide a subjective critique/summary of papers, patents, proceedings, and reports of a pertinent topic in the shock and vibration field. A literature review should stress important recent technology. Only pertinent literature should be cited. Illustrations are encouraged. Detailed mathematical derivations are discouraged; rather, simple formulas representing results should be used. When complex formulas cannot be avoided, a funtional form should be used so that readers will understand the interaction between parameters and variables.

Manuscripts must be typed (double-spaced) and figures attached. It is strongly recommended that line figures be rendered in ink or heavy pencil and neatly labeled. Photographs must be unscreened glossy black and white prints. The format for references shown in DIGEST articles is to be followed.

Manuscripts must begin with a brief abstract, or summary. Only material referred to in the text should be included in the list of References at the end of the article. References should be cited in text by consecutive numbers in brackets, as in the example below.

> **Unfortunately, such information is often unreliable, particularly statistical data pertinent to a reliability assessment, as has been previously noted [1].**
>
> **Critical and certain related excitations were first applied to the problem of assessing system reliability almost a decade ago [2]. Since then, the variations that have been developed and the practical applications that have been explored [3-7] indicate that . . .**

The format and style for the list of References at the end of the article are as follows:

- **each citation number as it appears in text (not in alphabetical order)**
- **last name of author/editor followed by initials or first name**
- **titles of articles within quotations, titles of books underlined**
- **abbreviated title of journal in which article was published (see Periodicals Scanned list in June and December issues)**
- **volume, number or issue, and pages for journals; publisher for books**
- **year of publication in parentheses**

A sample reference list is given below.

1. **Platzer, M.F., "Transonic Blade Flutter - A Survey," Shock Vib. Dig., 7, pp 97-106 (July 1975).**
2. **Bisplinghoff, R.L., Ashley, H., and Halfman, R.L., Aeroelasticity, Addison-Wesley (1955).**
3. **Jones, W.P., (Ed.), "Manual on Aeroelasticity," Part II, Aerodynamic Aspects, Advisory Group Aeronaut. Res. Devel. (1962).**
4. **Lin, C.C., Reissner, E., and Tsien, H., "On Two-Dimensional Nonsteady Motion of a Slender Body in a Compressible Fluid," J. Math. Phys., 27 (3), pp 220-231 (1948).**
5. **Landahl, M., Unsteady Transonic Flow, Pergamon Press (1961).**
6. **Miles, J.W., "The Compressible Flow Past an Oscillating Airfoil in a Wind Tunnel," J. Aeronaut. Sci., 23 (7), pp 671-678 (1956).**
7. **Lane, F., "Supersonic Flow Past an Oscillating Cascade with Supersonic Leading Edge Locus," J. Aeronaut. Sci., 24 (1), pp 65-66 (1957).**

Articles for the DIGEST will be reviewed for technical content and edited for style and format. Before an article is submitted, the topic area should be cleared with the editors of the DIGEST. Literature review topics are assigned on a first come basis. Topics should be narrow and well-defined. Articles should be 1500 to 2500 words in length. For additional information on topics and editorial policies, please contact:

Milda Z. Tamulionis
Research Editor
Vibration Institute
101 West 55th Street, Suite 206
Clarendon Hills, IL 60514

PUBLICATIONS AVAILABLE FROM
THE SHOCK AND VIBRATION INFORMATION CENTER
CODE 5804, Naval Research Laboratory, Washington, D.C. 20375

	PRICES Effective - 15 Jan. 1981 U.S.	FOREIGN
SHOCK AND VIBRATION DIGEST		
SVD-13 (Jan. - Dec. 1981)	$100.00	$125.00
SHOCK AND VIBRATION BULLETINS		
SVB-47	$ 15.00	$ 18.75
SVB-48	30.00	37.50
SVB-49	30.00	37.50
SVB-50	60.00	75.00
SVB-51	100.00	125.00
SHOCK AND VIBRATION MONOGRAPHS		
SVM-2, Theory and Practice of Cushion Design	$ 10.00	$ 12.50
SVM-4, Dynamics of Rotating Shafts	10.00	12.50
SVM-5, Principles and Techniques of Shock Data Analysis	5.00	6.25
SVM-6, Optimum Shock and Vibration Isolation	5.00	6.25
SVM-7, Influence of Damping in Vibration Isolation	15.00	18.75
SVM-8, Selection and Performance of Vibration Tests	10.00	12.50
SVM-9, Equivalence Techniques for Vibration Testing	10.00	12.50
SVM-10, Shock and Vibration Computer Programs	10.00	12.50
SVM-11, Calibration of Shock and Vibration Measuring Transducers	25.00	31.25
SVM-12, Balancing of Rigid and Flexible Rotors	50.00	62.50
SPECIAL PUBLICATION		
An International Survey of Shock and Vibration Technology	30.00	37.50

To order any publication, simply check the line corresponding to that publication that appears below, and mail the postage free card. You will be invoiced at the time of shipment.

Please send the following publication(s) to me:

Name

Address

Mail invoice to: (if other than above)

____ SVD-13
____ SVB-47
____ SVB-48
____ SVB-49
____ SVB-50
____ SVB-51
____ SVM-2
____ SVM-4
____ SVM-5
____ SVM-6
____ SVM-7
____ SVM-8
____ SVM-9
____ SVM-10
____ SVM-11
____ SVM-12
____ International Survey

DEPARTMENT OF THE NAVY

NAVAL RESEARCH LABORATORY, CODE 5804
SHOCK AND VIBRATION INFORMATION CENTER
Washington, D.C. 20375

OFFICIAL BUSINESS
PENALTY FOR PRIVATE USE, $300

POSTAGE AND FEES PAID
DEPARTMENT OF THE NAVY
DOD-316

U.S. MAIL

The Shock and Vibration Information Center
Naval Research Laboratory
Code 5804
Washington, D.C. 20375

ANNUAL SUBSCRIPTION SERVICE PACKAGE FROM THE SHOCK AND VIBRATION INFORMATION CENTER (SVIC)

Basic Package Rate: $500. per year (on a fiscal year basis – 1 October to 30 September)

Note: Annual rate may be increased in multiples of $500 based upon organizational size or requirements.

The Basic Package Contains:

	Individual Price
– One subscription to the Shock and Vibration Digest, a monthly current awareness journal containing abstracts from the current literature, systematic literature reviews, informative feature articles, and many other useful features.	$100 per year
– One copy of each SVIC State-of-the-Art Monograph as issued (average one per year).	$20–$40 per copy
– One copy of each SVIC Special Publication issued, such as 1979 International Survey, (free on request to FY 80 subscribers).	$60 per copy
– Up to two registrations at the annual Shock and Vibration Symposium	$100 per registrant
– One set of the Shock and Vibration Bulletin (3–5 volumes of technical papers).	$100 per set
– Up to five hours SVIC staff time for information consultation, search, and analysis.	$250.00

Timely availability of newly generated technical information is a valuable resource. The cost is small. The return is great. Let SVIC serve your information needs in the shock and vibration area.